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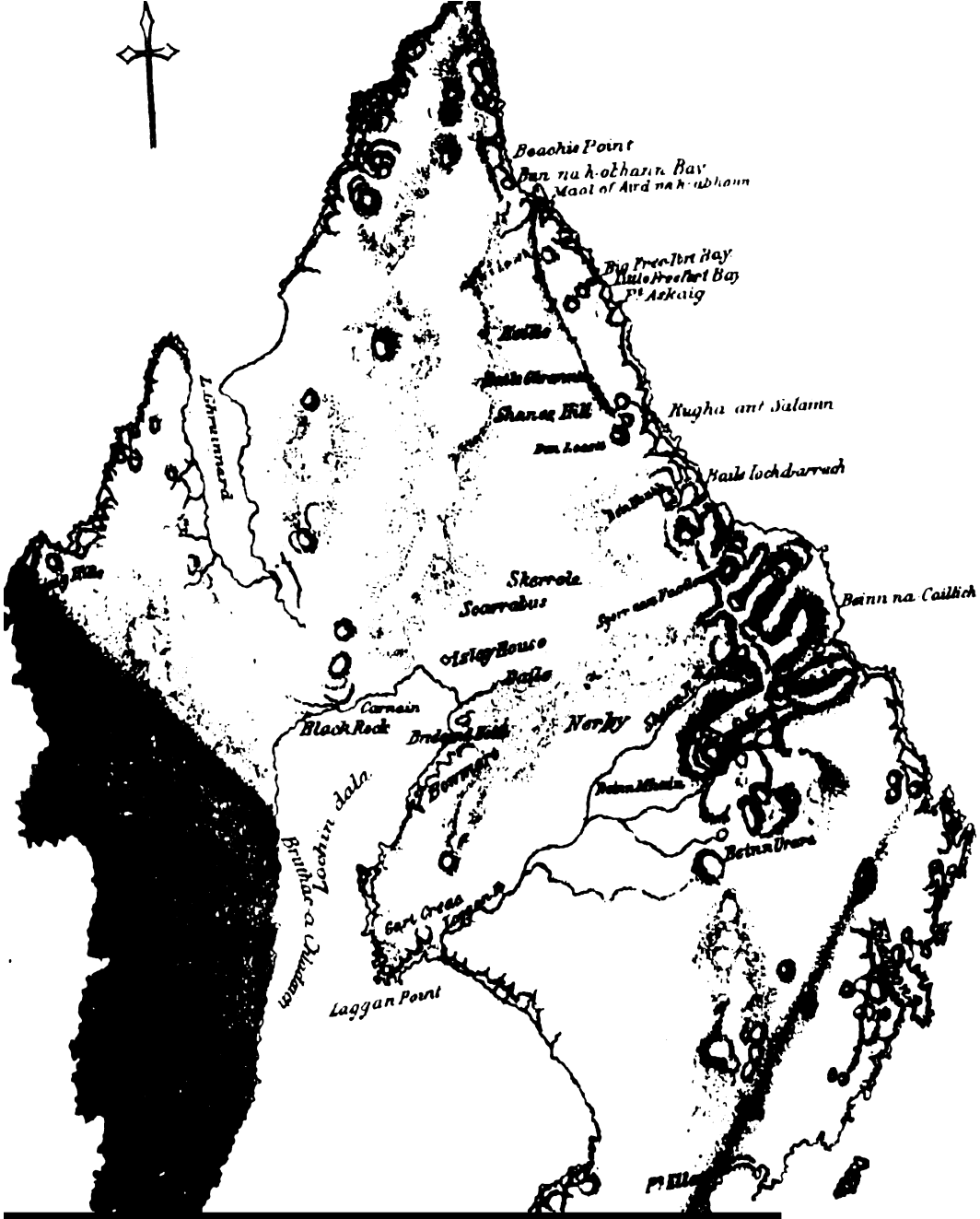

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OF THE

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VOL. V.

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TRANSACTIONS

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I.—Notes *on a* Till *or* Boulder Clay *with* Broken Shells, *in the Lower Valley of the River Endrick, near Loch Lomond, and its Relation to certain other Glacial Deposits.* By Robert L. Jack, F.G.S., of the Geological Survey of Scotland.*

[Read 15th Jan., 1874.]

The eastern angle of Loch Lomond is at present being rapidly silted up with the detritus carried into it by the River Endrick. Many acres of land have been gained from the Loch during the lifetime of some of the present residents on its shores. From the eastern extremity of the Loch there stretches, for some miles inland, a broad alluvial flat, through which the lower part of the Endrick pursues its crooked course. It is impossible to doubt that when the great icy graving tool was withdrawn, an arm of the newly made lake covered the site of this extensive alluvial flat. During the intensest cold of the glacial period, the valley of the Falloch (the site of Loch Lomond) was filled by an ice-sheet of immense thickness, which scored the side of Ben Lomond with striæ (parallel to the direction of the valley) to the height of 2,250 feet above, while it grated over a bottom no less than 600 feet below the present level of the sea. At this period the Menteith Hills, which rise to 1,400 feet, and whose tops present a perfect example of a *moutonné* outline on a large scale,†

* Of the facts mentioned in the following paper, those which were discovered in carrying on the Geological Survey are communicated, with the permission of the Director-General, in anticipation of the official Maps and Memoirs.

† This appearance is so marked from the southern side of the Carse of Stirling, that the range is known to the inhabitants of Kippen and Buchlyvie as "The Scolloped Hills."

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were overridden, and the Campsie and Kilpatrick Hills, though rising to 1,894 feet, were buried beneath the sheet of ice which flowed south-eastward out of the Highland glens. By contouring the bottom of the lake (from the data afforded by the soundings on the Admiralty Chart), I have found that there are no less than twelve separate basins between Ardlui and Balloch. These hollows are, without exception, elongated in the direction of the valley, and follow pretty nearly the sinuous line laid down on the Ordnance map as the boundary of the counties of Dumbarton and Stirling—a line which probably corresponds pretty closely to the course of the Falloch before Loch Lomond existed. The hollows are divided one from another, not by steep scarps, but by undulations so gentle that when the contour of the bottom is drawn to a true scale, they are hardly appreciable by the naked eye.* The shallows and deeps, when the geology of the neighbourhood comes to be examined in detail, will probably be found to correspond respectively with the outcrops of harder and softer bands of the upturned Silurian strata, which strike across the lake from south-west to north-east, and they may also be supposed to depend in some degree on the varying width of the preglacial valley.

It is not, however, my intention at present to recapitulate the evidence on which Loch Lomond is claimed as an example of a glacier-formed lake, but merely to make such a sketch of the physical geography of the district as will render intelligible the peculiarities of the deposits to be described.

It has already been observed, that when the ice-sheet was at its thickest it overflowed the Menteith, Campsie, and Kilpatrick Hills, and this is attested by the glacial striæ and the "carry" of the drift. But, as Mr. Dugald Bell has pointed out,† there were periods when the attenuated ice-sheet was divided by the minor hill-ranges that opposed its course, and was forced to round them and to stream through the valleys intersecting them from west to east. This view, I may say, is amply supported by the striæ mapped by myself in carrying on the Geological Survey;‡ the high grounds being crossed by striations from

* See Mr. J. Geikie's *Great Ice Age*. Appendix D.

† "Notes on Cross Striæ at Possil, near Glasgow."—*Trans. Geol. Soc., Glasgow*, Vol. IV., pp. 223 and 304.

‡ The striæ referred to will be found in the forthcoming Geological Survey Sheets, Nos. 30 and 31.

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N.W. to S.E., while the lower Clyde Valley, the Blane-Glazert Valley, the Endrick-Carron Valley, and the Forth Valley are swept by east and west striations.

When the ice had degenerated from a continuous "*nappe*," bearing down (in this district) from the N.N.W. to a series of separate glaciers streaming from west to east over the low passes of the Campsie Hills, the erosion of a new set of lakes would be begun nearly at right angles to the older set, and this erosion would be much facilitated by the circumstance that the courses of the protruding tongues of the shrinking ice-sheet would lie mainly among Sandstones of Lower Old Red and Lower Carboniferous age, much softer than the Silurian rocks enclosing Loch Lomond in its upper part. Theoretically, we should look for lakes in localities where the ice-streams or glaciers would be subjected to strangulation from the narrowing of their respective beds, and accordingly we find broad alluvial flats in several such situations, which it requires no great stretch of imagination to regard as silted-up lake basins, viz.:—in the Endrick-Blane Valley, the one above referred to as flanking the lower reaches of the Endrick, and which is merely a prolongation of Loch Lomond; in the Blane Valley proper, the one extending from the confluence of the river with the Endrick to Duntreath Castle; and in the Endrick Valley, the one stretching from Newtown of Fintry to the Gonachan. In the case of the Duntreath Castle basin, the cause of "strangulation" is obviously to be found in the hard trap escarpments and magnificent volcanic "necks" overlooking Strathblane. The sudden contraction of the Endrick Valley at its issue from between the fine trap escarpments at Fintry could not fail to increase the intensity of the erosion on the site of the Gonachan basin. It is not impossible that the rock-basin of Loch Lomond may be continuous from the mouth of the Endrick up the Blane Valley to Duntreath Castle, as the rock is nowhere seen in the bottom of the valley, and the lower part of the valley is flanked by deep drift deposits, which may conceal a broad rock-basin. It is, however, probable that a gentle rise of the Sandstone bottom about Catter Burnfoot, divides this corner of the rock-basin (which, had the country beyond offered a level bed for the passage of the ice, would naturally have terminated the loch), from the depression higher up the valley, due to the strangulation of the glacier.

The elevation (20 feet) of Loch Lomond above the sea is so

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trifling that there is no difficulty in classing it with the sea lochs which indent the western coast of Scotland. All these sea lochs are shallow at their outlets, and would become fresh-water lakes, like Loch Lomond, on a very slight elevation of the land. In fact, it may be regarded as in a manner an accident that Loch Lomond is not now an arm of the sea. A depression of 20 feet, or the removal of the superficial deposits traversed by its short outlet, the Leven, would restore it to its former condition.

In the course of my work on the Geological Survey to the south of the eastern angle of the Loch, and its silted-up continuation above referred to, it fell to my lot to map out a deposit whose relation to the already known members of the glacial series seemed to deserve particular attention.

The deposit is a true typical Till, in every respect analogous to the Old Boulder Clay or Till of the Lowlands of Scotland. In a matrix of stiff unstratified clay, brown in colour, like the subjacent Old Red Sandstone rock, are scattered stones of varying sizes up to several feet in diameter. These are blunted, smoothed, and marked with striations in all directions, but most frequently in the direction of their longer axes. The Till undergoes local variations, but on the whole may be described as above. It presents, however, one remarkable peculiarity to distinguish it from the common Till of the country. It contains worn and broken fragments of marine shells.

I shall now describe briefly the various exposures of the Till which have come under my observation. I am indebted to Mr. Robert Etheridge, Jun., F.G.S., Acting Palæontologist to the Geological Survey of Scotland, for naming some of the shells mentioned in this paper, and for many valuable notes. Messrs. J. Bennie and A. Macconochie also obliged me by washing a quantity of the Till for minute organisms.

Ross Burn, Ross Priory, Right Bank, about 400 Feet North of 100 Feet Contour Line.—Altitude above sea level, judging by the fall from the contour line, say 80 feet. Six feet of brown Till, exhibiting—what is occasionally noticeable in the common till—a tendency to horizontal arrangement in the scratched stones. One layer, somewhat more gravelly in appearance than the rest, yielded a fragment of *Cyprina Islandica*.

Ross Burn, Right Bank, at 100 Feet Contour Line.—20 feet of Till. Not otherwise distinguishable from ordinary till than by a rather smaller proportion of stones to clay than is usual. Stones almost all well scratched. (Observed a few of granite.) A small proportion rounded. Shell fragments scattered throughout. *Cyprina Islandica* and *Trophon clathratum* recognisable.

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Ross Burn, Right Bank, beside Tullochan Mill Lade.—Estimated height 320 feet. Six feet of ordinary Till, with well-scratched stones in a brown matrix. Shell fragments rare, and much worn. *Astarte sulcata* recognisable.

Kilmaronock Village, between Bridgend and United Presbyterian Manse, in Roadside Drain.—Height, say 125 feet. Brown Till, with shell fragments.

Blairrenich Burn, Kilmaronock—Angle West of Cambusmoon Cottage, Right Bank.—Say 130 feet high. Eight feet of Till. Matrix stiff brown sandy clay. Stones fairly numerous and large, and well scratched. Of 100 stones split up for the purpose of striking an average, 34 were Silurian, 9 quartz, and 57 Old Red, the latter being the rock *in situ*. Shell fragments numerous. The upper half of the Till rather less stoney in parts than the lower, but the shells equally distributed throughout. *Cyprina Islandica* and *Astarte sulcata* recognisable. This section is clear, and unobscured by the usual *talus* of rubbish, which is here constantly cleared away by the stream. I should particularly advise any geologist who may wish to get a fair idea of the deposit, to visit this section.

Blairrenich Burn, on Right Bank between last Section and Blairrenich Cottage.—Two more Sections, the lower shewing a tumbled face of about 12 feet, resting on brown flaggy Old Red Sandstone. The surface of the upper exposure is about 160 feet above the sea level. The shell fragments in both sections much broken, and rare.

Catter Burn, beween Catter Old Mill and Low Gartachorrans.—Height of surface, say 125 feet. 40 to 50 feet of well-marked brown Till, full of scratched stones, and containing a few fragments of *Cyprina Islandica*, and a whole valve of *Astarte compressa*.

River Endrick, Right Bank, between Railway Bridge and Park of Drumquhassle.—Till like that on Catter Burn, from level of river up to about 8 feet higher. Altitude of surface of Till, say 35 feet. Fragments of shells numerous, but very frail and imperfect. *Cyprina Islandica*, *Astarte sulcata*, and a fragment of *Balanus* were recognisable. The following were got on washing the clay (the list is by Mr. Etheridge):—

Globigerina bulloides, D'Orb.
Lagena globosa ? Montagu.
,, *marginata ?* Montagu.
,, *sulcata ?* W. & J.
Polystomella striato-punctata, F. & M.
,, (*nonionina*) *depressula?* W. & J.

In addition to the foregoing, the remains of the spine of an echinoderm, and a small roundish body which has the appearance of a much worn case of an entomostracan, were found; and also what appears to be the seed of a plant with a triradiate star on the surface, closely resembling the seed of the Carboniferous genus *Flemingites* of Carruthers.

In the above description nothing has been said of the relations of the shelly Till to other deposits. I shall now indicate what was observable on that point.

In Catter Burn, Ross Burn, and the higher sections on Blairrenich Burn, the shelly Till, although only in a few places

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actually seen in contact with the rock, is generally seen so near the latter that no other superficial deposits of importance can be supposed to intervene. It is possible that farther to the south-east the shelly Till may shade into the "true Old Boulder Clay;" and I confess that but for the shell fragments of the one, I should be unable to distinguish it from the other. On the other hand, it may be that the remains of a "true Old Boulder Clay" will be found to underlie the shelly Till; but I have not yet recognised them there. I believe, nevertheless, on grounds to be presently stated, that the shelly Till has its place *above* the Old Boulder Clay.

I am well aware that it is sometimes difficult to distinguish a clay of marine origin, when it happens to be crowded with dropped stones, from a true Till, the product of land-ice, and that careful investigation has often proved that animal remains said to have been found in the till, really came from stratified beds separable from that deposit. But I am confident that in this case the fact of the dispersal of worn shell fragments through the Till itself will stand any test to which it may be put. Moreover, the deposit, although fossiliferous, so exactly resembles the true Till elsewhere, that there is no good reason why an origin of a different nature should be assigned to it.

On referring to the Ordnance map,* it will be observed that the shells have been nowhere detected in the Till more than a mile south of the eastern part of Loch Lomond and its silted-up continuation. The farther the Till is traced from the Loch, the more rare and fragmentary do the shells become. The shells in the Till are as much boulders as the scratched stones themselves; and just as the boulders decrease in size the farther they have travelled from the parent rock, so also do the rubbed and crushed shells of the Endrick Valley Till.

The explanation which, I believe, agrees best with the facts observed with reference to the Till in question, is the same in principle as that supported by Mr. James Croll for the Shelly Till of Caithness.† The Till is, I believe, a product of land ice—the *moraine profonde* of a large glacier which filled up

* In the preceding and following descriptions of sections it is intended that the exact localities referred to should be capable of identification with the aid of the 1-inch Ordnance map.

† "The Boulder Clay of Caithness, a product of land ice."—*Geol. Mag.*, Vol. VII., p. 209.

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the lake, covered the islands—two of which rise to over 200 feet in height—and climbed the rising ground between the Leven and the Endrick to the height of 320 feet at least.

This glacier, in all probability, existed during the latter portion of the period (preceding the "great submergence" of the land) to which the confluent ice-sheet is referred. Professor A. Geikie, F.R.S., Mr. James Geikie, Mr. Bennie and others, have adduced proofs that the great ice-sheet period was interrupted by several intervals of milder conditions, when the ice melted from land and sea, and marine and terrestrial faunas and floras were re-established. Professor Geikie first drew attention to the stratified beds intercalated with the Till,* and Mr. James Geikie has recently given them a new importance by bringing forward evidence of the presence in Britain of palæolithic man at the time they represent.†

At the height of the glacial period the Irish Sea and the North Sea were both filled up with true land-ice, so that probably every form of marine life, except perhaps a few minute and hardy Foraminifera and Entomostraca, was banished for a time from our shores, at least as far south as the Bristol Channel. Whenever, therefore, the remains of a marine fauna are found among the deposits of this period (prior to the submergence), a mild interval must have intervened of sufficient duration to admit of the northward migration of the species from the habitats to which they had been driven by the protrusion of the ice. When, however, shells are found diffused throughout the Till itself, they must either, (1) have been derived from stratified beds deposited before the glacial period or during one of its milder intervals, or (2) they must have been living when the ice-sheet protruded itself over the sea bottom which they inhabited. If we account for a "shelly till" by the latter theory, we must suppose that the outer submarine edge of the glacier ploughed up the superficial deposits, including living and (if any) fossil marine animals, and that the confused mass thus pushed forward by the ice would be further augmented by the properly so-called terminal moraine—the accumulation of rock debris which had travelled *on* or *in* the glacier from the inland mountains to its outer edge. But such an accumulation, and especially its upper portion (the terminal moraine), could not fail to present a recog-

* *Trans. Geol. Soc., Glasgow*, Vol. I., Pt. 2 (1862).

† *Geol. Mag.*, Vols. VIII. & IX. (1871-72). See also *The Great Ice Age.*

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nisable stratification, the characteristic mark of arrangement by water. The Endrick Till at least, as has been already insisted on, possesses by no means this character. Moreover, instead of being distributed throughout the Till pretty equally over an area of a good many square miles, as in the case in question, the shells would be found only along one or more lines or bands, marking the successive limits of the extension of the glacier. This will be better understood by reference to diagram, fig. 1.

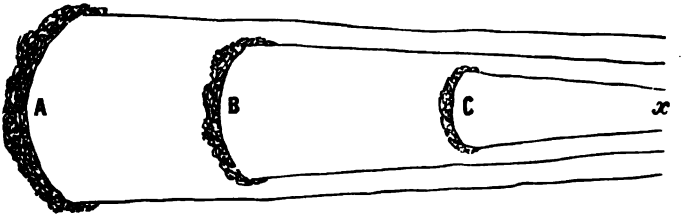

Fig. 1.—End of Glacier at three successive stages.

Let us suppose that after a mild period the ice has retired and the sea has resumed possession back as far as the point x. A marine fauna has been established over the sea bed back to x. The glacier now advances to the line A, where it leaves a belt of superficial deposits (mingled with exuviæ of animals) ploughed up from the space between x and A. The glacier once more retires to x, and re-advances to B, to which line it pushes the deposits accumulated between x and B. A similar sequence of events takes place when the ice retires to x and re-advances to C. If the ice at its second or third advance reaches as far as A or beyond it, the debris (including animal remains) is pushed forward, and forms a belt as before. As I understand this theory, it demands that shelly boulder clays (perhaps *all* boulder clays) can only occur in heaps along the outer limits of a glacier, and can only be formed while the outer edge of the glacier is *advancing*.

We are forced, therefore, to return to our first assumption, viz., that the broken shells in the Till have been derived "from stratified beds deposited before the glacial period, or during one of its milder intervals." It seems much more probable that the shells lived during one of the mild intervals towards the close of the "pre-submergence" period, than that they are of pre-glacial age. In the latter case, the shells would have been

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crushed, and jostled, and ground along with the other materials of the *moraine profonde*, under the enormous pressure of an ice-sheet thick enough to leave on the sides of Ben Lomond the markings already referred to, and to surmount the Campsie Hills. In such circumstances they could hardly have escaped being crushed to powder. Further, the shelly boulder clay would in that case surely have been, at least in parts, eroded and cut into by an unfossiliferous Till belonging to some of the subsequent periods of glacial extension. Besides, the long eastern tongue of the Loch, now silted up, would not be eroded till the ice-sheet had ceased to be confluent, and had sent a spur up the Endrick-Blane Valley; and judging from the direction of the glacial striæ and the positions where the shelly Till has been observed, for instance, in the Catter Burn, the latter is more likely to have derived its shells from the silted-up corner than from a fjord of the dimensions of the present lake.

On Ross Burn, at a lower level than the lowest exposure of the Till on that burn—say 65 feet above the sea—there is a section as follows:—

b. Coarse gravel, old alluvium of burn. 2 feet.

a. Stiff iron-bound gravel: stones not large, generally of shingly shape, many scratched; alternating with clayey sand. The whole full of broken shells, of which the following were alone recognisable:— 4 feet.

Cyprina Islandica.
Mytilus edulis.
Astarte compressa, Mont.
Littorina litorea.
Trophon, Sp.

This deposit has a sort of dip or cross-bedding inclined towards the Loch. From the fact that the shells of the Till are all present in this deposit, and are also in better preservation, it is possible that those in the Till were derived from the stratified beds, and not *vice versâ*. It is possible, in short, that we have here a fragment of the marine bed that supplied the shell-boulders to the Till, the scratched stones accompanying the shells having been washed from an older boulder clay. In that case its deposition would imply a depression of 65 feet with reference to the present sea level. I could, however, see no direct evidence on this point from superposition.

I have been careful to give the heights of the various expo-

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sures. At all events, it is useful knowledge. But, on the assumption that the shelly Till is a product of land ice, the mere altitude at which the shells are found proves nothing as to depression of the land, but only gives a minimum thickness for the glacier whose *moraine profonde* it is supposed to be. The presence of the shells in the Till proves, however, that when they lived the land was at or below its present level, as a very slight elevation of the land would have made the fjord a fresh-water lake.

In its passage over the bed of a fjord, such as interglacial Loch Lomond, a glacier would sweep up dead shells, whether lying loose on the bottom or buried in clay or gravel beds. These, and many rolled water-worn pebbles, would be mixed up with striated stones and other materials of the *moraine profonde.* No Till that I know of is entirely free from rounded water-worn pebbles, and the shelly Till contains no more of these than are to be accounted for by its passage over an arm of the sea, and across the strike of the quartz conglomerates that go to form a great portion of the lower islands and shores of the lake.

During the construction of the Forth and Clyde Railway, some beds were discovered at Croftamie (Drymen Station),* which have an important bearing on our present inquiry. The locality is a few yards east of the stone bridge on the road from Catter Mill to Kilmaronock Parish Church.

The section in the railway cutting was as follows, the height of the surface being 121 feet above the sea:—

"Stiff Till containing a large quantity of stones, some of a round form, apparently water-worn, others angular, and many of them of great size." 12 feet.

Blue clay, containing "a small round stone," and near its base, which rests on broken sandstone, a fragment of a deer's horn, 11½ inches in length, and the following shells:— 7 feet.

Cyprina Islandica.
Astarte compressa.
Fusus antiquus.
Littorina litorea.
Balanus.

* "Memorandum of shells and a deer's horn found in cutting of the Forth and Clyde Junction Railway, Dumbartonshire." By James Macfarlane, W.S., communicated by John Alex. Smith, M.D.—*Proc. Roy. Phys. Soc., Edin.*, Vol. I. pp. 163 (26th *March*, 1856) and 247. See also Geikie, *Trans. Geol. Soc., Glasgow*, Vol. I., Pt. 2, p. 70.

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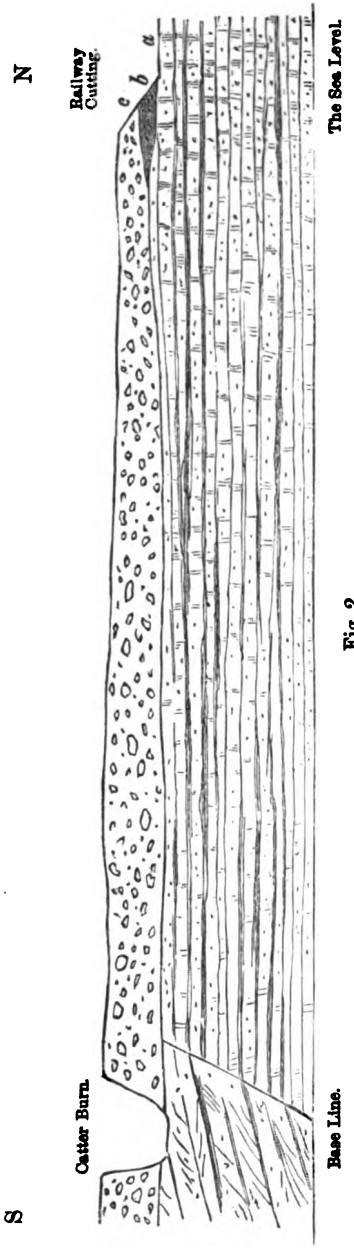

Fig. 2.

Section from Catter Burn, near Gartocharran, to Forth and Clyde Railway.

(Scale 120 feet to the inch.)

c. Shelly Till 12 feet thick at the railway cutting—40 feet at the burn.

b. Clay with marine shells and reindeer's horn—6 feet thick.

a. Old Red Sandstone.

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Professor Owen described the antler as being that of "a young or female reindeer of the existing species; and if, as is most probable, a female, of the large variety called 'Carabou' by the Hudson's Bay trappers."

The railway cutting at this point is only 220 yards to the north of the bluff of Till with a few shell fragments already described as occurring in Catter Burn. At the present day, the "facing" of the cutting obscures the geology, but the Till may be seen here and there at the top of the section, and the rock at the bottom. In one place (west of the bridge) a laminated clay is seen resting on the rock. The Till of the cutting, as far as one could judge from digging with a hammer, exactly corresponds with the Till of Catter Burn close at hand; and I have no doubt whatever that it is the same deposit. The shells, as already mentioned, are very scarce in the Catter Burn Till, and I do not wonder that in the neighbouring Till of the railway cutting they should have escaped observation. Indeed, I should have been much surprised if they had been discovered except by a person who came to look for them, convinced that they were to be found. I confess that I had mapped the Catter Burn Till as an ordinary till, nothing unusual having been observed in it, until on finding shell fragments elsewhere I came back to look for them there.

Unfortunately the section on the burn is tumbled and confused at this point by débris; but from what is to be seen, I infer that the shelly Till occupies the whole bank from the top to the rock, near the level of the stream. Fig. 2 is a section on a true scale from Catter Burn to the railway.

We have here additional evidence of an interglacial period before the great depression, when the sea resumed its sway over the Loch Lomond fjord and the reindeer browsed on its shores. The depression at this time amounted to a minimum of 108 feet (120 – 12). Afterwards—still before the great submergence—the glacier again filled up the valley, and mounted the rising ground between the Lower Endrick and the Leven to a height of at least 320 feet.

The chief reason for dating the shelly Till before the great submergence has not yet been touched on. It is found in the direct infraposition of that deposit to a series of sand, gravel, and clay beds so thick, and rising to such a height, that no other submergence of which we have any proof is sufficient to account

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for it. On the bank of the River Endrick, near the Park of Drumquhassle, the shelly Till is succeeded by a considerable thickness of mud, finely laminated clay, sand, and gravel. The section has been rendered rather indistinct by landslips, but the superposition of the stratified bed on the Till is unquestionable. Mounting the bank at this point, the stratified beds can be traced north-eastward along the railway nearly to Balfron Station; northward they can be traced beyond Drymen; eastward (in a fragmentary and denuded condition) to near Killearn; and southward to Craighat on the Stockiemuir Road. It thus covers, either continuously or in detached fragments, an area which I estimate at about five square miles. Its junction with the shelly Till, on the bank of the Endrick, stands about 35 feet above the sea, and the deposit rises near Cairnlee to 262 feet, it being continuous between these two localities. I have only seen the shelly Till underlying it at the railway bridge spanning the Endrick; but the railway cuttings and several streams, which make deep sections of the superficial deposits, expose an underlying till which is, so far as I have seen, without shells. Among these streams are Drumbeg Burn, east of Drymen, the Allt Quhar, the Endrick, near Gartness Corn Mill, and the Carnock and Dualt (Dhu Allt) Burns. According to the theory of the origin of the shelly Till above presented, I should consider it possible, though not very probable, that in the two last localities that deposit should be present. In the other cases I should think it hardly possible.

It will be obvious that a stratified deposit of the extent and at the altitudes of the one above referred to, is of great importance and deserves close investigation. I cannot, however, in the meantime, do more than refer to some of its most salient features. To a geologist who could have been on the spot while the excavations for the railway were going on, much information, now lost, would doubtless have been accessible.

Generally speaking, the stratified sands, clays, &c., form soft, undulating, round-backed hills, very much resembling the "drums," which form a characteristic feature of the Till in some parts of the country. The drum in the case of the Till, however, I believe, with the majority of geologists, to be the shape in which the deposit was made; while in the sand and clay "drums" the manner in which the stratified beds are cut off by the slopes of the surface proves that their shape is due to denudation. (It

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must be remembered that I am not describing kaims.) Occasionally, as at the Dunmore Tilework, near Gartness, the surface is flat, a circumstance due, I believe, to the fact that the denuding forces—probably subaërial—found it easier to remove a sand bed from the top of a clay bed, than to excavate the clay bed itself. The stratified beds generally, as seen in the railway and stream cuttings, are approximately horizontal, those of sand and gravel being frequently cross-bedded and abruptly cut off, as if denuded by streams or currents. The sand is sometimes a remarkably fine, white, soft dust, like flour. Perhaps, however, the most remarkable portions of the beds now exposed are those to be seen in the railway cutting near Gartness Station, where "ballast" is being dug. Here is seen a thickness of about 15 feet of sand, with cross-bedded patches and nests of gravel and clay, having near the top (covered in one place by 2 feet of stratified clay) a bed of stiff clay full of stones, some of them water-worn, the greater proportion blunted, like the stones of a till, and a few striated. The stony clay probably indicates the agency of ice —possibly floating ice—during the submergence period; but I do not care at present to hazard any more definite suggestion regarding it. At Drumquharn Tileworks, 8 to 12 feet of fine laminated clay overlie a bed of sand and gravel, which is iron-bound at top, 18 feet deep at least. I was informed that shells are sometimes got in the sand, but the manager of the works had seen none.

On the north side of the road above the railway, between Gartness Station and the Allt Quhar viaduct, the gravel has yielded shells. These were found in a fragmentary condition, and much rolled and water-worn. The following shells were recognised by Mr. Etheridge :—

Balanus, Sp. (fragment).
Anomia?
Pecten Islandicus?
Cyprina Islandica.
Mytilus? (fragment).
Astarte compressa, Mont.
A. sulcata, Da Costa.
Littorina litorea.
Trophon clathratum, Linn.=*Fusus scalariforme*, Gould.
(A worn specimen.)
Buccinum (fragment).

Mr. Thomas F. Jamieson, F.G.S., in his well-known paper

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"On the History of the Last Geological Changes in Scotland,"* describes shortly the stratified beds above referred to, and gives the following list of shells obtained, in 1864, from a point on the railway cutting about 120 feet above the sea-level :—

Species.	Living on the Coasts of Britain.	Living to the South of Britain.	Living within the Arctic Circle.	Living on the E. Coast of N. America.	Living in the N. Pacific.
Anomya ephippium, Linn.	×	×	×	×	
Astarte compressa, Mont.	×		×	×	
A. sulcata, Da Costa, var. *Elliptica*, Brown.	×		×	×	
Buccinum undatum, Linn.	×	×	×	×	
Cardium echinatum, Linn.	×	×	×	×	
Cyprina Islandica, Linn.	×	×	×	×	
Littorina litorea, Linn.	×	×	×	×	
L. squalida, Brod. and Sow.			×	×	
Mya truncata, Linn.	×	×	×	×	×
Natica affinis, Gmelin = *N. clausa*, Brod. and Sow.			×	×	×
Pecten Islandicus, Müller.			×	×	
Tectura virginea, Müller.	×	×	×		
Trophon clathratus, Linn.			×	×	
T. truncatus, Strom.	×		×	×	

	Per cent.
British,	71·4
Southern,	50·0
Arctic,	100·0
N. E. American,	92·8
N. Pacific,	14·2†

The Rev. H. W. Crosskey, F.G.S., also made a list of the shells from this locality, which has, however, not yet been published.

In a gravel pit at Wester Gateside, near Drymen, on the road to Gartness, I found, at the height of 210 feet, rolled fragments of the following shells :—

* *Quart. Journ. Geol. Soc., Lond.*, Vol. XXI. (1865), p. 161. See especially p. 172, and Appendix, No. 4.

† Since the above was written, I learn that Mr. Jamieson also saw in 1864, "near the Endrick Water, at the railway bridge, fragments of shells imbedded in hard stony mud, and also in a silty clay containing small stones, some of which were glacially striated." This, Mr. Jamieson thinks, was on the south side of the Balloch Railway, between Gartness and Drymen. (Letter from Mr. Jamieson to Mr. D. Bell, 16th July, 1874.) The section of Till with shells underlying clay and sand beds referred to in the text, is on the *north* side of the Endrick Railway bridge.

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Astarte sulcata, Da Costa.
Cyprina Islandica.
Nucula, Sp.

The stratified drifts above described probably date from a period subsequent to the deposition of certain kaims which occur to the north of the Drymen and Stirling Road, at a higher level, and when the cold which strewed the surfaces of these and other kaims with travelled blocks, dropped from floating ice, had much abated. The shells probably lived during the re-elevation of the land.

It may be remarked, that when the gravel was deposited at the height of 262 feet, a narrow strait at the low water-shed of the Bog of Ballat, near Balfron Station, must have connected the basin of the Clyde with that of the Forth.

To the retreat of the ice-sheet which produced the shelly Till, are probably to be referred some at least of the moraines which extend up the Falloch from the head of Loch Lomond to the very watershed, dividing the Falloch from the more important valley of the Fillan. The watershed is little over 600 feet above the sea, and is less than 100 feet above the alluvial flat at Crianlarich Inn, Strathfillan. The latter valley, it will be seen from the Ordnance map, makes a curve below Crianlarich Inn, nearly at right angles to its former course, and thereafter receives the name of Glendochart. Whenever a thick glacier came down Strathfillan into the narrower Glendochart, and abutted against the steep slope of Stob-Coire-Bhuide, it must have found farther progress in undiminished volume down the glen very difficult, and an arm would certainly escape down the Falloch. To the last such glacier I ascribe the *moraine profonde*, referred to above as the shelly Till, and to its retreat the moraine mounds resting on the watershed. Had these watershed moraines been deposited in its retreat by any prior glacier, they could not have failed to be at least flattened, if not swept away, by the glacier which left the shelly Till behind it. My reason for believing that the shelly Till was produced by a glacier which had its gathering ground partly in the region drained by the Fillan, is that a glacier nourished solely in the Loch Lomond valley could not have climbed the rising ground between the Leven and the Endrick to the height (320 feet) to which the shells have been traced, but would have made its way down the Leven valley;

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and moreover it could not have left its moraines on the water-shed. That the Till in question was produced prior to the great submergence, is proved by the superposition of deposits of that age.

I do not wish to be understood to indicate a doubt that a glacier occupied Glen Falloch during the period of local glaciers which followed the re-elevation of the land, or that the moraines of the lower part of the valley may have been deposited by such a glacier.

So far back as 1822, Mr. J. Adamson described* several accumulations of shells on the margin of Loch Lomond. The first of these was a calcareous "tuff" or stalagmite in cavities and joints of the Silurian limestone at Arrochymore Point. *Mytilus edulis* is the only shell he names from this locality, which stands 8 or 10 feet above the lake. I lately saw a piece of this "tuff" in the hands of Mr. A. Macfarlane, Balmaha. The shell named by Mr. Adamson was the only one which I could recognise, although there were several others. In other two localities, one, on Inch Lonaig, opposite Luss, and the other "on the lands of H. M'D. Buchanan, Esq., near the south-east angle of the Loch," the shells occurred between the highest and lowest levels of the water in a bed of brown clay, under a covering of coarse gravel. The list he gives is as follows:—

Mr. Adamson's List.	Species to which Adamson's may be referred.
ECHINODERMATA.	
Echinus esculentus.	
CRUSTACEA.	
Balanus communis.	Forbes considered this to be identical with *Lepas balanus*, Linn. (*Mem. Geol. Survey*, Vol. I., p. 430); which is regarded by Darwin as a synonym of *Balanus porcatus*. Da Costa, of the Mammalian and Red Crags and glacial deposits of Scotland, Uddevalla, and Canada.
B. rugosus.	*B. crenatus*, Bruguiere.

* "Notice of Marine Deposits on the margin of Loch Lomond."—*Mem. Wern. Soc.*, Vol. IV. p. 334 (14th *Dec.*, 1822).

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Mr. Adamson's List.	Species to which Adamson's may be referred.
LAMELLIBRANCHIATA.	
Anomya ephippium, young of.	Probably *P. tigrinus*, Müller.
Pecten obsoletus.	
Cardium edule?	
Nucula rostrata, young of.	If this be *N. rostrata*, Macgillivray, it is considered by Jeffreys to be only the compressed form of *Leda minuta*, Müller, a living British form (*Brit. Conch.*, Vol. II., p. 158), and found in many upper tertiary deposits.
Tellina tenuis.	
Venus Islandica.	*Cyprina Islandica.*
V. striatula.	Probably *V. Gallina*, Linn., both a British living and glacial form.
GASTEROPODA.	
Buccinum reticulatum.	*Natica reticulata*, Linn.
Nerita glaucina.	Probably *Natica catena*, Da Costa.

Mr. David Robertson, F.G.S., who has already rendered important services to this department of geology, is now engaged in investigating these beds; and I am content to wait for his results before saying more than that the Loch Lomond deposits are evidently of a much later date than the shelly gravels at Gateside and Gartness.

Mr. Robertson has given an account of some fossiliferous clay beds on the edge of the lake at Ross Arden, opposite Inch Tavannach.* He describes them as "the common mussel, the common whelk, and I may say the common *Rissoa ulva*," together with a species of foraminifer. The shell bed, Mr. Robertson writes, is "covered by a soft vegetable mould about 20 inches thick, being itself fully that thickness, and resting on what seemed to be vegetable mould. It was seen, I understand, at or near the level of the water, and is said to extend 30 to 40 feet into the Loch. It is evidently a very recent deposit of estuary shells, probably dating from a time immediately prior to the last elevation of the land."

Mr. James Bennie informs me that shells have also been found in a fine brick clay in the bed of a streamlet some little distance from Balmaha. They were mostly *Cyprinæ*, and in fragments, but their state of preservation was good, the epidermis still retaining its place and its natural colour.

* "On the Clay beds of Ross Arden on the banks of Loch Lomond" (*June*, 1864).--*Proc. Nat. Hist. Soc., Glasgow*, Vol. I., p. 92.

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Several cases of shelly Tills in maritime districts have been noted by various observers. A glance at these will suffice to shew how much they have in common with the Till of the Endrick Valley.

The well known Till of Caithness, which has yielded many shells to the labours of Messrs. C. W. Peach, Cleghorn, Dick, Smith, and Jamieson, bears evidence of having come from the south-west, and consequently across the Moray Firth. The striæ point from south-west to north-east, and some of the included stones could only have come from the region between Elgin and Peterhead.

Mr. John Carrick Moore, so long ago as 1850, announced * that shell fragments had been found by him in the till of the western part of Wigtownshire. Mr. R. D. Irvine, in carrying on the Geological Survey, has recently detected a similar till at different points in the same locality,† and has added considerably to the list of fossils. The striæ proved that the ice-sheet came from north to south, up Loch Ryan, to the Mull of Logan.

A till containing fragments of *Cyprina Islandica* occurs in the County of Durham.‡ The striæ are sometimes from the north and north-east, and sometimes east and west (probably from west to east). Those from the north-east prove that the ice-sheet crossed a part of the bed of the North Sea, the ice from the north of England and south of Scotland having been doubled back on the coast by the resistance of the Scandinavian ice-sheet.

In West Lancashire, the "lower boulder clay" of Blackpool has yielded shells. Mr. De Rance, who describes the deposit,§ regards it as of marine origin; but it is easy, from his description, to identify it with the lower till of Scotland. The striæ of North Lancashire run from north to south, the lake district having sent off an ice-sheet which would be compelled by the pressure of Scotch and Irish ice to hug the coast.

* "Notice of the occurrence of Marine Shells in the Till."—*Quart. Journ. Geol. Soc.*, Vol. VI., p. 388.

† *Memoirs of the Geological Survey of Scotland.* Explanation of Sheet I. (1872), Sect. 12; and Explanation of Sheet III. (1873), Appendix.

‡ "On the Glaciation of the Counties of Durham and neighbourhood. By R. Howse."—*Proceedings of the North of England Inst. of Mining Engineers, May*, 1864.

§ "On the Glacial Phenomena of West Lancashire and Cheshire." By C. E. De Rance, F.G.S. of the Geological Survey of England and Wales (22nd *June*, 1870).—*Quart. Journ. Geol. Soc.*, Vol. XXVI., p. 641.

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Mr. Mackintosh * found a similar shelly till at Dawpool in Cheshire—a locality to which the same remarks apply.

Commenting on the Lancashire and similar shelly tills, Mr. R. H. Tiddeman, † who gives a sketch-map shewing striæ parallel to the coast-line, makes the following remarks :—

"It is a point insisted on by some geologists that wherever either rolled stones or marine shells are found in the boulder clay, it must be of marine origin. I do not think that either of these characters is infallible. Mr. Croll has shewn that the Caithness Till, which contains shells, need not necessarily be marine, but may have been formed by the ice-sheet working over a previous sea-bed, and pushing the shells on to the land. In this way shells scratched and broken may be found at very much higher levels than the sea in which they lived and died. They are there as much boulders as the scratched stones alongside of them, and are no more evidence of the drift in which they lie having been formed under the sea than Spirifers and *Producti* found in limestone river gravel would be proof of its being marine. In very many places the ice-sheet must have passed over what had previously been the sea-bed, and if its course took it thence inland, we should be surprised not to find sea-shells mixed with the drift formed by it. Nor can rolled stones be considered a better test, for, under similar circumstances, they must be brought up from the old sea-bed on to the land." I quite agree with these observations.

It will be seen that the various beds which it is the immediate object of this communication to describe end with the great submergence. They may be summed up as follows—(the table should be read upwards, or in chronological order):—

c. A great extent and thickness of stratified mud, clay, sand, and gravel, resting on the shelly Till (*b*) at the level of 35 feet above the sea, and reaching a height of 262 feet above the sea, containing, in the shape of beds of stiff clay with stones, indications of the presence of ice—perhaps floating ice—during part of the time. At three localities, 120, 160, and 210 feet respectively above the level of the sea, this deposit has yielded water-

* "On a Sea-coast section of Boulder Clay in Cheshire." By D. Mackintosh, F.G.S. (8th *May*, 1872).—*Quart. Journ. Geol. Soc.*, Vol. XXVIII. p. 388.

† "On the evidence for the Ice-Sheet in North Lancashire and adjacent parts of Yorkshire and Westmoreland." By R. H. Tiddeman, M.A., F.G.S., of the Geological Survey of England and Wales (19th *June*, 1862), *Quart. Journ. Geol. Soc.*, Vol. XXVIII., p. 471.

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worn marine shells of species almost all now living in the British seas. The deposit indicates, therefore, a climate little more severe than our own. It is referred, for reasons stated above, to the later stages of the great submergence period, when, after the deposition of kaims at higher levels, the land had risen so much as to be only about 260 feet below its present level.

b. A Till containing broken shells, resting on the stratified bed (*a*). The Till is traceable by means of the shells to a height of 320 feet above the sea-level, and is believed to be the *moraine profonde* of a large glacier or ice-sheet, which, in crossing the south-east corner of the Loch Lomond fjord, mingled the remains of an interglacial or preglacial shell-bed or beds with stones and clay, and crushed and rubbed them exactly as it did the included boulders. It is referable to the later stages of the first period of the glacial epoch, prior to the great submergence of the land.

a. A stratified clay (Croftamie) containing marine shells and a reindeer's horn. The shells indicate a climate not severe, though probably a little colder than the present climate of these latitudes. All the shells specifically distinguished are living in British seas. The land must have stood 109 feet lower than at present.—This deposit is interglacial, or preglacial—most probably interglacial. It underlies the shelly Till (*b*).

II.—*On the* Microscopical Structure *of* Red Quartz-Porphyry, *from the Old Red Sandstone of Logan Water, above Lesmahagow.* By Edward Hull, M.A., F.R.S., Director of the Geological Survey of Ireland.

[Read 11th Dec., 1873.]

Those who have followed the windings of the Nethan and Logan waters above Lesmahagow must have been struck by the beauty of the red porphyries which are interbedded with the Old Red Sandstone near its junction with the upper Silurian beds. This ground has been rendered classic for geologists through the labours of Mr. Robert Slimon, who has brought to light so many forms of extinct Crustacea, some of which are figured and described in Murchison's *Siluria.*

Having some years ago made a pilgrimage to this shrine of the

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great Pterygotus, I brought away with me a few specimens of the red porphyry above alluded to; and having recently submitted a thin slice (prepared by Mr. J. B. Jordan of the Mining Record Office) to microscopic examination, I venture to offer the results to my old colleagues of the Geological Society of Glasgow, as some little token of my desire to maintain the friendly intercourse which has for some years existed between us.

The section shews that the rock in question is an extremely interesting one of its class, as it contains a fair assemblage of minerals—for the most part, with the exception of the silica, well crystallised throughout. The rock itself would produce, if worked, a beautiful ornamental stone, and, I have no doubt, would polish well. Whether it is intrusive, or has been contemporaneously bedded, I am at present uncertain.* There are, however, several beds at intervals amongst the Red Sandstones and conglomerates of the district.

General Composition.—When the slice is viewed with the 2-inch object glass (magnifying 25 diameters), it is seen to consist of a reddish-brown felsitic mottled paste, in which are imbedded rounded grains of silica, numerous felspar crystals, greenish crystals and flakes of mica, and large crystalline grains of magnetite. The rock is, therefore, a quartz-porphyry, with mica as an accessory; and though containing the three constituents of granite, differs from a true granite, inasmuch as the paste consists of felspathic material instead of silica, which is the paste of all true granites.

Felspar.—The slice with polarised light shews that the felspar is of two varieties or species—orthoclase and a triclinic felspar, which may be either oligoclase or albite, probably the former. The triclinic species predominates, and on rotating the lower prism shews the fine parallel lines and coloured bands which characterise the group of triclinic felspars. One example is remarkably well developed, and is shewn in fig. 2.

The crystals of orthoclase are also well formed, and generally shew a banded structure parallel to the sides of the crystal, as shewn in figs. 1 and 3. These bands doubtless represent planes of growth, and are quite distinct from the parallel lines of the felspars belonging to the 5th system, which stretch from end to end of the prism.

* Since the above was written, I have been informed by Mr. J. Geikie that the porphyry is intrusive.—E. H.

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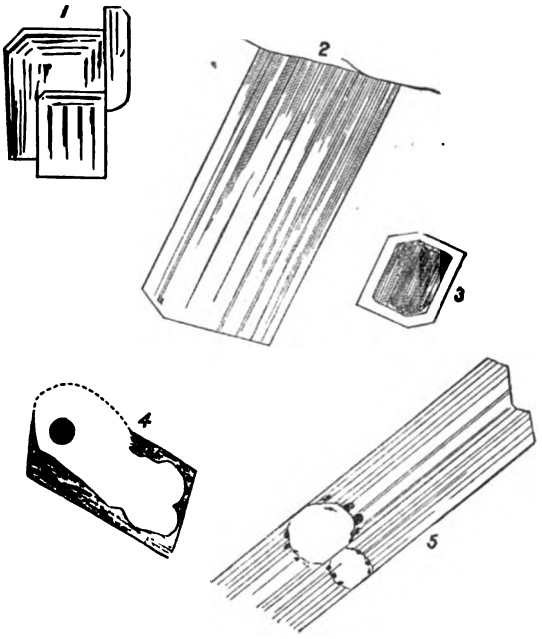
Quartz.—The quartz granules are round, or without crystalline form. Some of them contain cavities which are perfectly formed spheres, as in fig. 4.; others are oval; but it is seldom that they are so perfectly developed—the colourless centre deepening into the dark purple walls through a series of delicately blending rings of colour. Such perfect spheres can only, I should think, have resulted from the presence of a gas enclosed in a gelatinous and homogeneous paste, and pressing



outwards in all directions—a high temperature could produce the necessary elastic force; and we may suppose the silica to have been in the state here indicated at the time the cells were formed. I therefore consider these spheres to be "gas cavities."

Though examined with a magnifying power of 800 diameters, no good or undoubted case of a "fluid cavity" could be observed. The condition, therefore, under which the porphyry was formed must have been very different from those of true granites, the silica of which nearly always contains cells with fluid bubbles.

Mica.—The mica is scattered in numerous flakes throughout the mass. It is of a pale greenish-yellow colour, much scarred,

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and contains black grains of magnetite. Several well-formed crystals also occur, one of these, a hexagon, being specially noticeable. In another instance a crystalline flake has been formed round an amorphous grain of silica, shewing that this latter mineral has been the first to consolidate. The quantity of magnetite which is to be observed in the mica is remarkable, and may be considered as representing the excess of iron above that which has entered into the composition of the mica itself.

Magnetite.—Considering the species of rock, this mineral is remarkably abundant, occurring in large opaque grains throughout the other minerals, except silica, and, as already observed, specially in the mica. These grains are generally amorphous, but sometimes the angle of 90° of the cube is discernible. They are very minute—the largest not being more than the 200th of an inch in diameter, generally much smaller. As they do not occur enclosed in the silica, they seem to have consolidated subsequently to this mineral, but previously to the other minerals—whether mica or felspar—in which they are to be found imbedded.

Notwithstanding the large number of magnetite grains, the rock but very slightly affects the magnetic needle.

From the foregoing statements it would appear that the minerals crystallised in the following order :—First, the silica, then the magnetite, then the mica, and lastly the felspars; while the felspathic paste in which they are enclosed must have long retained a plastic state of consistency. Vapour of water does not appear to have been present, otherwise the silica would have remained in a gelatinous condition for a longer period, as in the case of the granites. The absence of fluid bubbles in the cells of the silica corroborates this view, and is in harmony with the phenomena observable with regard to the relative rates of consolidation of the component minerals.

The specimen under consideration affords an excellent illustration of the essential distinction between a quartz-porphyry and a granite, even when in the former all the constituents of granite are present.

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III.—*The* Post-Tertiary Fossiliferous Beds *of* Scotland. By Rev. H. W. Crosskey, F.G.S., and David Robertson, F.G.S.

XX.—KYLES OF BUTE.

The beds of clay which occur at many points in the Kyles of Bute constitute classic ground to the geologist, since among them the late Mr. J. Smith, of Jordanhill, first detected the existence of an Arctic fauna, and practically established a glacial epoch. In a previous volume of the *Transactions of the Geological Society of Glasgow*, one of the authors of these pages has given an account of Mr. Smith's researches (Vol. II., p. 228), and claimed for them that high place in the history of geology to which he believes them to be justly entitled. In a paper read to the Wernerian Society, 26th Jan., 1839, Mr. Smith described an excursion to the Isle of Bute, in company with Mr. G. B. Sowerby, for the purpose of dredging. On the northern extremity of the shore he found several valves of the *Pecten Islandicus*, and further search revealed them imbedded in a finely laminated clay, and associated with many other species of Mollusca not known as British, but living in northern latitudes.

Mr. Smith proceeded to make as complete lists as possible, both of the Mollusca living in the Clyde and the fossils of the clay bed, and formed the opinion "*that the indications of climate which could be gathered from the organic remains of these deposits pointed to a lower temperature than that of the present period.*" With great labour and skill he brought together evidence that the elevated marine beds of the district do not belong to one period, and divided the catalogue he first drew up into two parts—(1.) the older fossil shell bed, containing Arctic species; (2.) the younger, containing no species not found living in the present seas.

We have to acknowledge our own deep personal obligations to Mr. Smith, who, in his old age, went over with us the ground he had so thoroughly investigated, and placed freely at our disposal the information he had accumulated through a long series of years.

Tigh-na-bruaich.—Walking along the shore, and proceeding

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from high-tide mark to low, the following series of beds is passed over:—

(1.) Boulder clay, hard, compact, and unfossiliferous. It is red in colour, through the ferruginous character of the mica-schist, of which the included boulders largely consist, and which is the base rock on which it rests.

(2.) Succeeding the boulder clay is a highly laminated clay, remarkable for the decisiveness and freedom of its laminations. This laminated clay is precisely the same as that which occupies the same position at Paisley and many other localities. It was formerly supposed to be destitute of life, but we have detected in it specimens of *Polystomella striato-punctata.*

(3.) A shell bed follows the laminated clay, exceedingly rich in characteristic Arctic shells.

The composition of the shell bed is clay and sand, mixed in various proportions at different points; at times almost a pure sand and at times a pure clay being found with intermediate varieties. To the west of the pier, in the sand, we have found on digging an extensive bed of *Pecten Islandicus*, the shells having both valves united, and being in their natural position.

Saxicava (*Panopœa*) *Norvegica* also occurs in a thick clay, not 100 yards from this sand, of large size, standing upright as it lived.

Mya truncata, var. *Uddevallensis*, we have also collected at the same spot *in situ* in very large numbers; while *Astarte sulcata* and *Astarte compressa* could be picked out from the clay with both valves united; and very large valves of *Astarte borealis* have also occurred. To some of the boulders imbedded in the clay large specimens of *Balanus porcatus* were attached.

It will be observed that the true order of these beds (as was first pointed out by the Rev. A. M'Bride, of North Bute) is—

1. Boulder clay,
2. Laminated clay,
3. Shell bed,

being the reverse of the order in which they are passed over in walking from high to low-tide mark. The action of the sea has swept away the upper part of the beds, and since the denudation has been most complete where the waves have broken upon the shore, the lowest bed is the most thoroughly laid bare about high-tide mark.

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This order is invariable through the whole length of the Kyles, although one or other of the beds is occasionally wanting.

The shell bed was also exposed in the little stream near the hotel when the foundations of the bridge were dug.

The consistency of the beds being unequal, and their exposure to the denuding agency of the sea being also unequal, they stand at different heights, according to local circumstances. Fossils might appear to an inexperienced observer to be in the boulder clay, when they really occur at points where the fossiliferous bed is in immediate contact with it, the laminated clay being absent.

At very many points we have dug through the shell clay to the laminated clay, and through the laminated clay to the boulder clay, and at no point in the Kyles have we found shells in the boulder clay itself.

On the Bute shore, immediately opposite Tigh-na-bruaich, the same beds occur wherever any jutting point has saved them from denudation. At some points the *Mya* bed runs under the turf, and is above high-tide mark, while the boulder clay is exposed below it—the shell bed having been protected more perfectly than on the opposite side of the water. We have found *Saxicava* (*Panopœa*) *Norvegica* of very large size *in situ* in this locality. Any lump of clay dug out will yield many specimens of *Tellina* (*proxima*) *calcarea*.*

Balnakaile Bay.—In this bay, which is almost opposite to Colintraive pier, the glacial beds have been well preserved. They may be seen in the bed of a small fresh-water stream which discharges itself into the sea in the middle of the bay. Digging in the sides of this stream we have found *Saxicava* (*Panopœa*) *Norvegica* in its upright position, with other characteristic Arctic shells, evidently *in situ*.

On the left of the stream the shell bed may be seen extending under sands and gravels, which rise to the height of twenty to thirty feet. We have traced the shell bed also about a quarter of a mile inland in the wood on the left bank of the stream. The nature of the matrix in which the shells are imbedded varies from a loose sand to a tenacious clay.

Following the Rothesay road, in a slight bend of the Kyles opposite the farm-house, the shell bed has been found in great

* It is necessary to state that recent storms have swept away many of the beds in the localities scattered through the Kyles of Bute to which we have referred.

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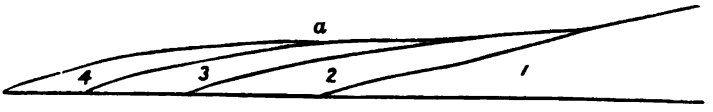
perfection. It is now almost washed away, but when we first visited it the shells were most abundant. Wherever a boulder protected the clay the larger Arctic shells were to be seen *in situ*. We have taken from this bed large numbers of *Pecten Islandicus*, with *Balanus porcatus* attached to their upper valves, and we have seen *Balanus porcatus* adhering to large boulders on the shore. In these beds, also, we have found *Balanus cariosus* (Darwin), the only specimen of this *Balanus* at present discovered in the fossiliferous clays, and *Modiolaria nigra*. The *Saxicava* (*Panopæa*) *Norvegica* we have dug out with both valves united.

The shell beds extend from high-tide mark towards the sea, and great care must be taken entirely to remove the sands and gravels containing recent species before beginning to collect specimens at all. Collections made from the mere surface debris are geologically worthless, since they will be found to contain arctic, raised beach, and recent species intermixed in inextricable confusion. The same order of succession may be observed here as in other parts of the Kyles, viz.:—(1.) Boulder clay; (2.) Laminated clay; (3.) Shell bed.

Following the Loch Ridden road, on the Colintraive side of the Kyles, in a small bay about a quarter of a mile from the pier a shell bed is exposed at low tide, which has been confounded with the *true glacial clay*. In this bed *Pecten maximus* and *Ostrea edulis* are found of enormous size, associated with *Aporrhais pes-pelicani*, *Lutraria elliptica*, *Psammobia ferroensis*, *Lucinopsis undata*, and other shells now living in neighbouring waters. The shells from this bed have frequently been included in lists of glacial shells, but careful examination shews that it rests upon the true glacial shell-bearing clay. We have traced the clay containing *Tellina calcarea* (*proxima*) and other Arctic shells to the point at which this *Pecten maximus* clay rests upon it, and have observed the succession which the following diagram illustrates.



1. Boulder clay.
2. Laminated clay.
3. Arctic shell clay.
4. *Pecten maximus* sand and clay.

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It is evident that at the point *a* great care must be taken not to confuse the contents of beds 3 and 4.

We have observed the same *Pecten maximus* bed cropping out in various districts—*e. g.*, at dead low-water near Tigh-na-bruaich, at Kilchattan Bay, and at Fairlie, and on the banks of the Irvine, about a mile from the sea.

Ettrick Bay.—This bay, on the Bute shore, near the westerly entrance to the Kyles, is so completely covered with sand as to obscure any discrimination of separate beds, but is deserving of mention as the locality in which *Astarte borealis* may be found in the greatest abundance. Many single valves of this shell may be picked up on the sands washed out from the clays they *cover*.

CONCHIFERA.

Anomia ephippium, Linn.	Common.
——— var. *aculeata*.	
Pecten Islandicus, Müller.	Common; valves united, and *Balani* attached to specimens with united valves.
Mytilus modiolus, Linn.	Common.
——— *edulis*, Linn.	Not so common as *M. modiolus*.
Modiolaria nigra, Gray.	One large valve.
Leda pernula, Müller.	Common.
——— *pygmæa*, Müller.	Common.
Axinus flexuosus, Mont.	Common.
——— var. *Gouldii*.	
Cardium fasciatum, Mont.	Moderately common.
Cyprina Islandica, Linn.	Common.
Astarte sulcata, Da Costa.	Common.
——— *compressa*, Mont.	Common.
——— *borealis*, Chemn.	Moderately common.
Tellina calcatrea, Chemnitz.	Common and large.
Scrobicularia prismatica, Mont.	Rare.
Mya truncata, Linn.	Common.
——— var. *Uddevallensis*.	Common.
Saxicava rugosa, Linn.	Common.
——— var. *Arctica*, Linn.	Common; large in size.
——— *Norvegica*, Spengler.	Rather rare; found with their valves together.

GASTEROPODA.

Chiton plates.	Much eroded.
Tectura virginea, Müller.	
Trochus tumidus, Mont.	Rare.
Lacuna divaricata, Fabr.	Moderately common.
Littorina litorea, Linn.	
——— *obtusata*, Linn.	

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Rissoa striata, Adams.	Moderately common.
——— *parva* var. *interrupta*, Mont.	Rather rare.
Skenea planorbis, Fabr.	Rare.
Odostomia spiralis, Mont.	Rare.
——— *undentata*, Mont.	Moderately rare.
Natica affinis, Gemel.	Common.
Trichotropis borealis, Brod.	Moderately common.
Buccinum undatum, Linn.	Common.
Trophon clathratus, Linn.	
——— var. *Gunneri*, Soven.	
——— *truncatus*, Ström.	
Fusus antiquus, Linn.	Common.
Pleurotoma pyramidalis, Ström.	Moderately rare.
——— *turricula*, Mont.	Large, moderately common.
Cylichna alba, Brown.	Moderately rare.
Utriculus obtusus, Mont.	Moderately rare.

OSTRACODA.

Cythere pellucida, Bain.	Moderately common.
——— *viridis* Müller.	Moderately common.
——— *lutea*, Müller.	Rather rare.
——— *limicola*, Norman.	Moderately common.
——— *pulchella*, Brady.	Rare.
——— *villosa*, G. O. Sars.	Common.
——— *concinna*, Jones.	Very common, and in fine condition.
——— *angulata*, G. O. Sars.	Common, and strongly marked.
——— *tuberculata*, G. O. Sars.	Common.
——— *Dunelmensis*, Norman.	Moderately common.
Cytheridea papillosa, Bosquet.	Common, large, and very fine.
——— *punctullata*, Brady.	Moderately common.
Eucythere argus, G. O. Sars.	Moderately common.
Loxoconcha tamarindus, Jones.	Rare.
——— *fragilis*, G. O. Sars.	Rare.
Cytherura nigrescens, Baird.	Common.
——— *similis*, G. O. Sars.	Moderately common.
——— *undata*, G. O. Sars.	Common, and in good condition.
——— *striata*, G. O. Sars.	Common.
——— *Sarsii*, Brady.	Rather rare.
——— *flavescens*, Brady.	Rare.
Cytheropteron latissima, Norman.	Common.
——— *nodosum*, Brady.	Rather rare.
——— *angulatum*, Brady and Robertson,	Rare.
Sclerochilus contortus, Norman.	Moderately common.
Paradoxostoma variabile, Baird.	Rather rare.
——— *ensiforme*, Brady.	Rare.

CIRRIPEDIA.

Balanus porcatus, Da Costa.	Abundant.
——— *crenatus*, Brug.	"
——— *Hameri*, Ascarrius.	"
——— *cariosus*, Darwin.	One specimen. This species is new to the Clyde glacial beds.
Verruca Strömia, Müll.	Rare.

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ECHINODERMATA.

Echinus drobachiensis, Müller	Abundant.
Starfish, disk, and ray plates.	Common.

HOLOTHUROIDEA.

Internal plates occur in the clay at Balnakaile Bay.

FORAMINIFERA.

Biloculina depressa, D'Orb.	Moderately common.
Triloculina oblonga, Montagu.	Rare.
Quinqueloculina seminulum, Linn.	Common.
——— *agglutinans*, D'Orb.	Rather rare.
Lagena lævis, Montagu.	Rather rare.
——— *sulcata*, W. & J.,	Rather rare.
——— *striata*, Montagu.	Rather rare.
——— *semistriata*, Will.	Moderately common.
——— var. *apiculata*.	Common.
——— *distoma*, Parker & Jones.	Moderately common.
——— *squamosa*, Montagu.	Rare.
——— *globosa*, Montagu.	Rather rare.
Dentalina communis, D'Orb.	Rare.
Cristellaria rotulata, Lamk.	Rare.
Polymorphina lactea, W. &. J.	Common.
——— *gibba*, D'Orb.	Rare.
——— *oblonga*, Brown.	Rather rare.
Uvigerina pygmæa, D'Orb.	Rather rare.
Bulimina marginata, D'Orb.	Rare.
Rotalia Beccarii, Linn.	Rare.
Polystomella striato-punctata, F. & M.	Moderately common.
——— *Arctica*, Parker & Jones.	Rare.
Nonionina depressula, W. & J.	Moderately common.
——— *asterizans*, F. & M.	Moderately common.
——— *turgida*, Will.	Rare.

A large number of species of Mollusca have been previously catalogued as occurring in the glacial clays of the Kyles of Bute, and we have ourselves collected many we have not enumerated. The beds have however been so washed by the sea, that it is almost impossible to discriminate not only between recent and fossil specimens, but between specimens belonging to the glacial clays and those belonging to the shell bed which rests upon it, and which must be referred to the period of the latest raised beach, and exhibits no Arctic conditions. We have thought it right therefore to circumscribe our list; and not to enumerate all the specimens we have found, but only those collected in positions about which there could be no doubt.

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IV.—*On the* First Appearance *of* Certain Fossils *in the* Carboniferous Strata *around* Beith *and* Dalry. By Robert Craig, Langside, Beith, *Corresponding Member.*

[Read 12th March, 1874.]

Having for a considerable period investigated the mode of occurrence and distribution of the fossils found in the carboniferous strata in the Beith and Dalry districts, I have thought that a few remarks upon the subject may not be without interest to the Society. It is not, however, so much the purport of this paper to give an exhaustive list of the organic remains found in the above districts, as to point out the beds in which the more common species make their first appearance, so far as has been observed. The better to understand this, it will be necessary to give a short description of the strata, while noting the principal fossils found in each bed.

1. The Carboniferous group of strata in the district average about 150 fathoms in total thickness, their base resting upon an accumulation of ash beds. This ash has been bored into for about 80 fathoms without finding its base, and it consists of red and green ash, more or less indurated, with intervening beds of doleritic greenstone. The first appearance of organic remains in the district occurs in this ash, a few fathoms below its upper surface, in the shape of carbonaceous impressions, but too much decayed for correct identification. These, as found at Tandlehill, Beith, in a railway cutting, were associated with thin layers of sedimentary deposits intercalated in the ash. A clay ash of uneven thickness completes the series, upon which lies a thin layer of coal, 4 inches thick, overlaid by a clay shale, 2 feet in thickness, very full of plant remains in a crushed and bad state of preservation—a species of *Calamite* and fragments of *Stigmaria* have, however, been identified. Upon this rests a bed of coal, 1 foot 4 inches thick, containing fragments of *Stigmaria* and *Sigillaria* converted into the sulphuret of iron.

2. Resting upon the coal is an argillaceous shale, the first bed, yet detected in the district, that contains the remains of a marine fauna. It is very fossiliferous, being almost built up of crushed shells, and has furnished about 50 per cent. of the genera, and one-third of the species found in the group of beds overlying it

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in the district. Of these there are 7 genera and 15 species of BRACHIOPODA, which are as follows, viz.:—

Crania quadrata, M'Coy.
Discina nitida, Phil.
Lingula mytiloides, Sow.
Orthis Michelini, Léveillé.
,, *resupinata*, Martin.
Productus longispinus, Sow.
,, *semireticulatus*, Mart.
,, var. *Martini*, Sow.
Productus spinulosus, Sow.
,, *scabriculus*, Martin.
,, *punctatus*, Martin.
,, *fimbriatus*, Sow.
Spirifera lineata, Martin.
,, *bisulcata*, Sow.
Streptorhynchus crenistria, Phil.

Of the LAMELLIBRANCHS there are 12 genera and 26 species, viz.:—

MONOMYARIA.

Avicula lævigata? M'Coy.
,, *Sp.* ?
,, *Sp.* ?
,, *Sp.* ?
Aviculopecten granosus, Sow.
Aviculopecten semicircularis, M'Coy.
,, *cælatus*, M'Coy.
,, *Sowerbii*, M'Coy.
,, *Knockonnensis*, M'Coy.
Pinna flabelliformis, Martin.

DIMYARIA.

Axinus axiniformis, Phil.
,, *carbonarius*, Portl.
Cypricardia acuticarinata, Arms.
Edmondia rudis, M'Coy.
,, *unioniformis*, Phil.
,, *oblonga*, M'Coy.
,, *scalaris*, M'Coy.
,, *Egertoni*, M'Coy.
Leda attenuata, Flem.
,, *oblonga*, M'Coy.
Modiola elongata, Phil.
Myacites sulcata, Flem.
,, *Sp.* ?
Myalina crassa, Flem.
Sanguinolites plicatus, Portl.
,, *subcarinatus*, M'Coy.

Of GASTEROPODA there have been found 8 genera and 15 species, viz.:—

Euomphalus radians, De Kon.
,, *Sp.* ?
,, *Sp.* ?
Loxonema Lefebvrei, Léveillé.
,, *sulcatula*, M'Coy.
,, *Sp.* ?
Macrocheilus acutus, Sow.
,, *Michotianus*, De Kon.
Murchisonia quadricarinata, M'Coy.
Natlcopsis variata, Phil.
,, *spirata*, Sow.
Pleurotomaria conica, Phil.
,, *expansa*, Phil.
,, *monilifera*, Phil.
,, *Yvanii*, Léveillé.
Trochus lepidus? De Kon.

The CEPHALOPODA are rather poorly represented, only 3 genera and 4 species having been detected, viz.:—

Actinoceras giganteum? Sow.
Nautilus quadratus, Flem.
Orthoceras cinctum, Sow.
,, *attenuatum*, Flem.

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Fish remains are found sometimes very plentiful in a thin layer about half an inch above the coal bed. Those mostly found on this horizon are the scales, spines, and bones of *Amphicentrum granulosum*, single teeth of *Pœcilodus obliquus*, *Deltodus*, *sp. nov.*, *Xystrodus*, *sp. nov.*, and the scales and teeth of *Megalichthys Hibberti*. In the body of the shale, but generally when nearing its upper surface, are occasionally found *Petalodus Hastingsiæ*, *Ctenoptychius serratus*, *Tomodus convexus*, and on its very surface, just below the limestone, *Psammodus rugosus*; *Helodus planus* is also found, and a small jaw with dentition of *Palæoniscus*, *sp.*?

In this shale CORALS are very rare, only one, a diminutive specimen of *Zaphrentis patula*, is found in the body of the shale; but on its upper layer, where it assumes a more calcareous character, small nests of *Lithodendron junceum* and *Lithostrotion striatum* are found. These small patches are from a few inches to a yard in diameter, shewing that the coral has had a comparatively short and, apparently, precarious existence. In the upper calcareous layer some of the large rugose corals put in an appearance; these are mostly specimens of *Cyclophyllum* and *Clisiophyllum*, and are very rare.

Various genera of CRINOIDEA are found in all parts of the bed, but are most plentiful in its upper half. Some fine fingers of *Poteriocrinus M'Coyanus* with crushed heads of the same are found, also the head of *Pisocrinus globularis*, and various stems apparently not described.

We have thus at the very base of this carboniferous group of strata, in a bed of shale about 3 feet thick, a great influx of a marine fauna, shewing that as soon as the sediment had commenced to settle upon the coal, marine forms of life had appeared and left evidence of their existence. In some places about 1 inch of fine sediment has been deposited before any organisms appear, but in general they are found resting close upon the coal. From about 1 to 2 inches above the coal *Lingula* and *Crania* first appear, the former very plentifully, but both in a crushed state; they then disappear, and are not found until in a like position above the 9-inch coal in the divisional shales of the lower limestone. In this shale the conditions appear to have been more favourable to the growth of the Lamellibranchs than to the Brachiopods; while the former are what may be called plump and well developed in size, the latter are generally stunted and diminutive compared with

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their representatives in the overlying strata; this is especially the case with the *Productæ*—the same species being found in the Productus-beds at Broadstone and elsewhere throughout the district, double and often quadruple the size of those found in this shale; however, this only refers to the Beith quarries; on the west side of the basin, in the Pudduff Burn, Kilbirnie, where this shale crops out with a depth of 12 feet and has a more calcareous character, the *Productæ* are as finely developed as in the higher beds at Beith, and here *Productus giganteus*, a shell not found in the shale at Beith, is plentiful, as well as *Athyris ambigua*, which is not found in the Beith quarries on a horizon below the coral shale.

3. Main Post.—Resting immediately upon the above shale lies the "main post," a bed of limestone that runs from 3 to 5 feet in thickness, and which is a very pure carbonate of lime, but has not produced many fossils fit for the cabinet; it is principally built up of the ossiculæ of a small and, as far as I am aware, an undescribed species of Crinoid. This Crinoid first appears in the shale below, where the bed assumes a calcareous character, and continuing upwards becomes immensely developed throughout the main post, until nearing its upper surface, where it gradually dies out, and its place is taken up by the corallites *Lithodendron* and *Lithostrotion*. This bed is hard and partly crystallised, breaking up into large angular blocks, and is therefore not so well adapted for as thorough investigation as softer strata. It has only added 2 genera and 5 species to that already found in the lower shale.

BRACHIOPODA.

Rhynchonella pleurodon, Phil.	*Spirifera glabra*, Martin.
Terebratula hastata, Sow.	var. *linguifera*, Phil.
	,, *pinguis*, Sow.

CEPHALOPODA.

Nautilus ingens, Martin.	*Actinoceras giganteus*, Sow.

The Lamellibranchs and Gasteropods are all but absent in this bed, but, as formerly stated, it is not rich in Molluscan remains. It is also rather poor in Fish remains, only 2 genera and 2 species are added to what is found in the inferior shale—these are *Cladodus mirabilis* and *Carcharopsis prototypus*; the former rather plentiful in some places, while only two specimens of the

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latter, as yet, have been found, and they are the only remains of this species that the carboniferous beds of the district have produced; but as they were both found in this stratum on different horizons, and about 300 yards apart, we may surmise that they are not the vestiges of a solitary intruder; still it is curious that no more of them have been as yet detected. One spine of *Oracanthus Milleri*, has been found in this bed, being its first appearance in the district, and palate teeth of *Psammodus rugosus* and *P. porosus*, continue along with species of Cochliodonts. Trilobites here make a first appearance, all in a fragmentary state; *Griffithides meso-tuberculatus* is the most common, but lately at Thirdpart, Beith, *G. Eichwaldi* was found on the same horizon. The Annelida also appear in this bed, good specimens of *Serpulites carbonarius* and *S. membranaceus*, are found although rare, and are generally confined to small circles. Near to its upper surface, nests of *Lithodendron* become common, and a few of the large rugose corals appear, but still rare. Polyzoa put in an appearance, but mostly confined to *Polypora dendroides*, &c.

4. Lithodendron Bed.—Resting upon the main post, but in general divided from it by a well marked line, is what I have here named the *Lithodendron* bed, from its being largely built up of this corallite. This bed, the "two feet stone" of the quarryman, has a thickness of from 2 to 3 feet, and has added 2 genera and 6 species of Molluscan remains to what has been found in the inferior beds. These are as follows:—*Productus cora*, *P. giganteus*, *P. Youngianus*, *Strophomena analoga*, *Sanguinolites iridinoides*, *Bellerophon cornu-arietes*. To the Fish remains we have added *Homocanthus* and single teeth of *Helodus planus*. The large rugose corals increase in this bed, but are still comparatively rare, the bed being almost one mass of *Lithodendron fasciculatum*. Otherwise it is not rich as a fossiliferous deposit.

5. Coral Shale.—Resting upon the above bed is the "coral shale," as I have named it here, from its having produced the greatest number of the large rugose Corals found in the district. These are mostly found in an argillaceous layer in the bottom of the shale. These Corals need not be named here, as they have been all given in Messrs. Young and Armstrong's list, published in the third volume of the Society's *Transactions*, and will be given in the table appended to this paper. This shale has a thickness of from 1 to 2 feet, and consists of alternate layers of argillaceous and calcareous shale. It is mostly in the argil-

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laceous layers that the large Corals are found, and taking the example of the beds in this district, it appears that a purely calcareous sea bottom was not favourable to the production of these large rugose Corals, that their true habitat was rather where a certain amount of argillaceous mud had been deposited with the calcareous matter. This is so evident, that at Trearne, where the upper series of the lower limestone is wrought, a Coral bed, similar in character to the one under consideration, but more indurated, is found, and the whole bed, as here, has to be turned into the refuse heap, being useless for commercial purposes from the amount of clay that it contains. Except the Corals, this shale is not very fossiliferous. It only adds 5 genera and 8 species to those known in the lower beds; these are, *Chonetes Laguessiana*, *Cypricardia rhombea*, *Solenimya primæva*, *Solenopsis imbricata?* *Retzia radialis*, *Orthoceras pygmæum*, and *O. laterale*. The Fish remains are not very plentiful, there has only been added to what the lower beds has produced a very fine spine, as yet undescribed, and a single tooth of what is probably an example of *Orodus cinctus*. Some good specimens of Polyzoa appear, various species of *Ceriopora*, *Glauconome*, and *Fenestella*, put in a first appearance (see table at end).

6. Blue Limestone.—Resting upon the Coral shale, is a post of blue flaggy limestone, very unevenly developed, increasing from 3 feet at Broadstone to 13 feet at Lyonshields and elsewhere, but generally from 3 to 5 feet. It is of a mixed character, thin layers of argillaceous shale intervening between the layers of limestones, and is at certain places rich in organic remains, in other places deficient in them. It adds only one genus to what has been found in the inferior beds—viz., *Conocardium aliforme;* but the following species appear here not found below:—*Productus aculeatus*, *Rhynchonella pugnus*, *Spiriferina octoplicatus*, *Terebratula hastata*, var. *vesicularis*, *Euomphalus pentangulatus*, *Loxonema constricta*, *L. curvilinea*.

The Fish remains are sometimes plentiful, but, except the following, they have all been detected in the subjacent beds. These are *Petalorhynchus*, *sp. nov.*, *Orodus*, *sp. nov.*, *Helodus didymus*, *H. conica*, *H. mammilaris*, *Orocanthus minor*, and *Glossodus marginatus*. A single scale of *Rhizodus Hibberti* was found, and some fin-bones and casts of bones of what has been taken for *Cladodus mirabilis* have been preserved.

7. White Limestone Post.—Above the "Blue limestone" lies

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the "White stone" of the quarrymen. It runs from 6 inches, as at Overtown, to 10 feet, in some places at Broadstone, and in the latter locality often running into lenticular nests of shale. It is not rich in shells, but abounds in Fish remains. Only a few of these are new, and belong to species still undescribed; the most plentiful are those belonging to the Cochliodonts and to the genus *Pœcilodus*—the latter disappears in the first mentioned bed a few inches above the lower coal, and is rare in the intervening strata, until we reach the "Blue stone," where a few specimens occur, but here they reappear in numbers that may be called profuse. No additions have been made from this post to the shell remains found in the series, so far as I am aware.

This concludes the sub-series of the lower limestone, a blank taking place in the limestone at this point, which is filled up with 40 feet of shales, of mixed character, including a thin bed of coal 9 inches thick, &c. (see table of strata at end of paper). These shales have an extensive range, being found under modified conditions at Auchenmade and Auchenskeoch, Kilwinning, and on the west side of the basin in the Pudduff Burn, Kilbirnie, and Park, Lochwinnoch, near its N.E. outcrop.

8. Resting upon the above limestone bed is a calcareous shale, shading at certain places into one of bituminous character. It does not produce many specimens fit for the cabinet, but *Dentalium priscum* (?) appears for the first time in the bed, and a small Pecten (sp. ?) has been found. *Myalina crassa*, found in the first shale bed, but not found in the intervening strata, reappears in this bed. These, with a few others found in subjacent beds badly crushed, make up the shell remains yet detected. The only Fish remains yet detected are teeth and scales of *Megalichthys Hibberti*, and teeth of *Pœcilodus obliquus*.

9. Nine-inch Shale.—A thin bed of coal lies upon the above shale, overlaid by an argillaceous shale, 9 inches thick. This shale is very rich in Fish remains, and has yielded a number of good specimens. These are mostly similar in character to those found in the first shale bed, above the lower coal, but a few small Cochliodonts are found, new to the series, and are still undescribed. The teeth of *Rhizodus* make their first appearance in the distrct in this shale; a single scale of this fish was found in the "Blue limestone," and another one in the "White limestone" bed, but no teeth have as yet been detected on a horizon

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lower than this shale bed. A very fine specimen of a large head plate belonging to this fish was found lately in this shale. It was discovered by Mr. James Craig, Gateside, an intelligent workman, who in his occupation as a quarryman has preserved a large number of specimens, some of them new, and which, but for his care, would probably have been lost to science. It does not yield any good specimens of shell remains, but both *Lingula* and *Crania* reappear. None of these have been found in the intervening strata above the first shale bed, except a single specimen in the main post, but they reappear here, and die out in similar circumstances to that in the first shale bed.

10. Limestone.—Above this shale lies a band of impure limestone, 10 inches in thickness, containing nothing new from that observed in the subjacent beds, and is not very fossiliferous.

11. Arenaceous Shale.—Over this last bed rests an arenaceous shale, in which no marine fauna have been detected; only a few badly preserved stems of *Sigillaria*, and faint markings of a fern, *Pecopteris*, are all that have been met with in it as yet. Above this, beds of a clay ash appear, intercalated with a band of bituminous shale, which is unfossiliferous, overlaid by 3 inches of impure clay ironstone, then 6 inches of bituminous shale, succeeded by 20 feet of calcareous shale containing thin beds of limestone, complete the divisional shales at Beith. The last mentioned beds have not been well examined, from want of opportunity; but, as far as they have been cut into, they do not appear to contain anything different from what has been detected in the inferior beds, and further, appear not very fossiliferous. In a bed of shale close to the under surface of the higher series of this lower limestone, a small variety of *Rhynchonella pugnus* is found. This is the only place where this variety has been detected in the lower limestone series here, but it has been found very plentiful in the upper series at Bowertrapping, Dalry.

Physical Conditions.—The fossiliferous beds described in the above paragraphs include about 60 feet of strata when they are on in full. Various changes appear to have taken place during their deposition, but they are greater after the subseries of the limestone had been laid down. An oscillation of old land surface and sea bottom had taken place during the deposition of the "Blue stone" beds. This and the "White stone" both give evidence of being laid down in a shallower sea, with a more uneven bottom than the one in which the serial beds

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below had been laid down in. The 9-inch coal with land plants furnish evidence of an old land surface. The 9-inch shale resting upon this coal and the band of impure limestone give evidence of submergence, followed by upheaval and volcanic eruption. In the Hessilhead Burn, Beith, the ash is amorphous, and about 9 feet thick; in the Broadstone quarries, where it has been laid open, it is about the same, but divided into two beds by a bed of shale. After this, a gradual sinking of the sea bottom has taken place where a series of shale and limestone bands has been laid down, culminating in the upper series of the lower limestone.

In conclusion, I have to thank Mr. John Young of the Society, for his kind assistance in identifying the fossils found in these beds, and also Mr. Woodward, of the British Museum, for his kindness in sending me the names of a few of the rarer Fish remains. A few Fish remains have been found that are still undescribed, and it is probable that a few other organisms may have been detected that have not come under my notice.

Not having entered into the examination of any of the small microscopical fossils, no notice is here taken of them; and not having paid much attention to the Crinoidea, a number of species as well as genera may have been overlooked. Although found in all the beds of the sub-series, it is not until we reach the Encrinital beds of the upper series of the lower limestone that we find them in profusion; still it appears that the greater part of the genera and species are represented in the sub-series, but from the scarcity of preserved heads it is very difficult to arrive at their correct identification.

NOTE.—Since this paper was read, in looking over a collection of shells that had been laid past from the shale above the lower coal, I found a crushed shell that looked like a *Bellerophon Urii*. I shewed the specimen to Mr. Young, and he had not a doubt about it. I had seen crushed fragments often, but from their state of preservation there was a doubt about their identity, but now we find that *B. Urii* has put in its appearance at the very base of these Carboniferous beds. *Nucula* has been found in this bed, and also a very fine specimen of *Sanguinolites iridinoides*, a shell that I have set down as first appearing in the "*Lithodendron* post."

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TABLE OF STRATA

As found in an old quarry at Broadstone, wrought in the sub-series of the lower limestone, farther to the dip than any of the other quarries in the district.

Name of beds taken in descending order.	Fathoms.	Feet.	Inches.
Calcareous shale with intervening bands of limestone,	...	20	...
Bituminous shale with band of clay ironstone,	...	2	...
Clay ash, unfossilferous,	...	5	..
Bituminous shale,	...	1	3
Clay ash, unfossiliferous,	...	2	...
Arenaceous shale with remains of land plants,	...	4	...
Impure limestone band with marine fauna,	...	...	10
Shale of mixed character, with marine fauna,	...	...	9
Coal,	...	...	9
Shale of mixed character with marine fauna,	...	4	...
White limestone with marine fauna,	...	7	6
Blue limestone with marine fauna,	...	5	...
Coral shale band with marine fauna,	...	1	11
Lithodendron limestone with marine fauna,	...	2	...
Main post limestone with marine fauna,	...	4	6
Argillaceous shale with marine fauna,	...	3	...
Coal,	...	1	4
Clay shale full of the remains of land plants,	...	2	...
Layer of coal,	...	...	4
Clay ash from 2 to 30 feet,	...	...	...
Beds, cut into, containing red shaly sandstone, with two beds of sedimentary clay, with plant remains,	...	11	...
Volcanic ash, bored into, with intervening beds of doleritic greenstone, about	80	...	...

NOTE.—The three last mentioned beds were ascertained by bores put down just outside of the carboniferous outcrop, and in a cutting on the Beith Branch Railway; the others are taken from the quarry section, as mentioned above.

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Species.	Shale above Lower Coal.	Main Post Limestone.	Lithodendron Limestone.	Coral Shale Band.	Blue Limestone.	White Limestone.	Shale of Mixed Character.	Shale above 9-inch Coal.	Arenaceous Shale.	Undescribed Shales, &c.
Zoophyta.										
Alveolites septosa, Flem.	×		×	×						
Amplexus coralloides, Sow.			×	×	×					
,, *Henslowi*, M. Edw.				×	×					
,, *spinosus*, De Kon.				×						
Clisiophyllum bipartitum, M'Coy.	×	×	×	×	×					
,, *coniseptum*, M. Edw.				×						
Lophophyllum eruca, M'Coy.				×						
Cyathophyllum expansum, M'Coy.				×						
,, *paracida*, M'Coy.				×						
,, *Wrightii*, M. Edw.	×	×	×	×	×					
Cyclophyllum Bowerbankii, D. and T.		×	×	×						
,, *fungites*, D. and T.		×	×	×	×					
Heterophyllia mirabilis, Duncan.						×				
Lithodendron fasciculatum, Flem.	×	×	×	×	×					
,, *irregulare*, Phil.			×	×						
,, *junceum*, Flem.			×	×						
Lithostrotion Portlocki, M. Edw.				×						
,, *basaltiforme*, Phil.	×		×	×						
Michelina tenuisepta, Phil.				×	×					
Syringopora ramulosa, Goldf.				×	×					
,, *Sp.* ?			×							
Zaphrentis Bowerbankii, M. Edw.			×	×						
,, *cylindrica*, M. Edw.				×						
,, *Phillipsi*, M. Edw.				×						
,, *patula*, Mich.	×						×			×
Echinodermata.										
Archæocidaris Urii, Flem.							×			
Pisocrinus globularis, De Kon.	×			×	×					
Poteriocrinus M'Coyanus, De Kon.	×	×	×	×	×					
,, *crassus*, Miller.	×	×	×	×	×		×			
,, *Sp.* ?	×		×		×		×			
Rhodocrinus, Sp.	×			×						
Annelida.										
Serpulites carbonarius, M'Coy.		×	×		×					
,, *membranaceus*, M'Coy.		×	×		×					
Spirorbis, Sp.				×						

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Species.	Shale above Lower Coal.	Main Post Limestone.	Lithodendron Limestone.	Coral Shale Band.	Blue Limestone.	White Limestone.	Shale of Mixed Character.	Shale above 9-inch Coal.	Arenaceous Shale.	Undescribed Shales, &c.
Crustacea.										
Griffithides meso-tuberculatus, M'Coy.		×	×		×					
,, *Eichwaldi*, Fischer.		×			×					
Polyzoa.										
Ceriopora interporosa, Phil.				×			×			×
,, *similis*, Phil.				×			×			
Carinella cellulifera, Ether.				×						
Fenestella plebeia, M'Coy.				×	×		×			
,, *nodulosa*, Phil.				×			×			
,, *carinata*, M'Coy.				×	×	×	×			
,, *flabellata*, Phil.				×	×	×	×			
,, *frutex*, M'Coy.				×	×					
,, *membranacea*, Phil.				×						
Glauconome bipinnata, Phil.	×			×	×	×	×			
,, *grandis*, M'Coy.				×			×			
,, *gracilis*, M'Coy.				×		×	×			
,, *pulcherrima*, M'Coy.	×			×	×		×			
Polypora dendroides, M'Coy.		×	×	×						
,, *tuberculata*, Prout.				×						
,, *verrucosa*, M'Coy.				×						
Rhabdomeson gracile, Phil.				×						
Sulcoretepora parallela, Phil.				×						
Vincularia ornata, Eichw.				×	×		×			
				×						
Brachiopoda.										
Athyris ambigua, Sow.				×	×					×
,, *Royssii*, Léveillé.			×	×	×	×				×
Chonetes Laguessiana, De Kon.				×						
Crania quadrata, M'Coy.	×							×		
Discina nitida, Phil.	×		×		×	×	×	×		×
Lingula mytiloides, Sow.	×	×						×		
Orthis Michelini, Léveillé.	×			×	×					×
,, *resupinata*, Martin.	×				×					
Productus fimbriatus, Sow.	×	×	×	×	×	×				×
,, *giganteus*, Martin.			×		×					
,, *punctatus*, Martin.	×	×	×	×	×	×	×			×
,, var. *elegans*, M'Coy.			×	×	×					×
,, *longispinus*, Sow.	×	×	×	×	×	×	×	×		×
,, *scabriculus*, Martin.	×			×	×	×		×		×
,, *semireticulatus*, Mart.	×		×	×				×		×
,, var. *Martini*, Sow.	×									×
,, *spinulosus*, Sow.	×		×	×	×					

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Species.	Shale above Lower Coal.	Main Post Limestone.	Lithodendron Limestone.	Coral Shale Band.	Blue Limestone.	White Limestone.	Shale of Mixed Character.	Shale above 9-inch Coal.	Arenaceous Shale.	Undescribed Shales, &c.
Brachiopoda—*Continued.*										
Productus sinuatus, D' Orb.			×	×	×					
,, *Youngianus*, Dav.	×		×	×	×	×				×
Retzia radialis, Phil.				×						
Rhynchonella pleurodon, Phil.		×	×	×	×	×				×
,, *pugnus*, Mart.		×			×					
Strophomena analoga, Phil.			×	×	×					
Spirifera bisulcata, Sow.	×	×	×	×	×	×	×	×		×
,, *glabra*, Mart.		×	×	×	×	×				
,, var. *linguifera*, Phil.		×			×					
,, *lineata*, Mart.	×	×	×	×	×					
,, *pinguis*, Sow.		×	×		×					
Spiriferina octoplicata, Sow.					×		×			×
Streptorhynchus crenistria, Phil.	×			×						
,, var. *radialis*, Phil.	×			×						
Terebratula hastata, Sow.		×	×		×					
,, var. *sacculus*, Mart.				×	×					
,, var. *vesicularis*, De Kon.					×					
Lamellibranchiata (Monomyaria).										
Avicula lævigata, M'Coy.	×									
,, *laminosa*, Phil.	×									
,, *Sp.* ?	×									
Aviculopecten fimbriatus, Phil.	×						×			
,, *granosus*, Sow.	×				×		×			
,, *semicircularis*, M'Coy.	×									
,, *Sowerbii*, M'Coy.	×									
,, *tessellatus*, Phil.					×					
,, *Knockonnensis*, M'Coy.	×									
Pinna flabelliformis, Mart.	×		×		×	×	×			
Lamellibranchiata (Dimyaria).										
Axinus axiniformis, Phil.	×									
,, *carbonarius*, Port.	×									
Conocardium aliforme, Sow.	×				×					
Cypricardia acuticarinata, Armst.	×									
Cypricardia rhombea, Phil.				×						
Cardiomorpha oblonga, Sow.	×				×					
Edmondia rudis, M'Coy.	×							×		

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Species.	Shale above Lower Coal.	Main Post Limestone.	Lithodendron Limestone.	Coral Shale Band.	Blue Limestone.	White Limestone.	Shale of Mixed Character.	Shale above 9-inch Coal.	Arenaceous Shale.	Undescribed Shales, &c.
LAMELLIBRANCHIATA (DIMYARIA)—*Continued.*										
Edmondia unioniformis, Phil.	×							×		
,, *oblonga*, M'Coy.	×							×		
,, *scalaris*, M'Coy.	×									
Leda attenuata, Flem.	×									
,, *oblonga*, M'Coy.	×									
Modiola elongata, Phil.	×									
Myacites sulcata, Flem.	×	×								
Myalina crassa, Flem.	×						×	×		
Nucula gibbosa, Flem.	×									
Sanguinolites plicatus, Portl.	×									
,, *iridinoides*, M'Coy.	×		×							
,, *subcarinatus*, M'Coy.	×									
Solenimya primæva, M'Coy.	×									
Solenopsis imbricata ? De Kon.				×						
GASTEROPODA.										
Euomphalus radians, De Kon.	×									
,, *helicoides*.	×									
,, *pentangulatus*, Sow.							×			
Dentalium priscum ? Goldf.							×			
Loxonema Lefebvrei, Léveillé.	×			×						
,, *constricta*, Sow.					×					
,, *curvilinea*, Phil.					×					
,, *sulcatula*, M'Coy.	×									
,, *Sp.* ?	×									
Macrocheilus acutus, Sow.	×				×					
,, *Michotianus*, De Kon.	×									
Murchisonia, Sp. ?	×									
,, *quadricarinata*, Phil.	×									
Naticopsis variata, Phil.	×									
,, *plicistria*, Phil.	×									
Nerita spirata, Phil.	×									
Pleurotomaria conica, Phil.	×									
,, *expansa*, Phil.	×									
,, *Sp.* ?	×									
,, *monilifera*, Phil.	×									
,, *Yvanii*, Léveillé.	×				×					
Trochus lepidus ? De Kon.	×									
NUCLEOBRANCHIATA.										
Bellerophon cornu-arietes, Sow.			×		×	×				
,, *decussatus*, Flem.					×					
,, *Urii*, Flem.	×									

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Species.	Shale above Lower Coal.	Main Post Limestone.	Lithodendron Limestone.	Coral Shale Band.	Blue Limestone.	White Limestone.	Shale of Mixed Character.	Shale above 9-inch Coal.	Arenaceous Shale.	Undescribed Shales, &c.
Cephalopoda.										
Nautilus quadratus, Flem.	×									
,, *ingens*, Sow.		×	×		×					
Actinoceras giganteum, Sow.		×	×		×					
Orthoceras attenuatum, Flem.	×			×				×		
,, *cinctum*, Sow.	×			×			×			
,, *cylindraceum*, Flem.	×									
,, *undatum*, Flem.				×			×			
Pisces.										
Amphicentrum granulosum, Dr. Young.	×				×			×		
Cladodus mirabilis, Ag.		×	×		×	×				
,, *striatus*, Ag.					×	×				
Cochliodus acutus, Ag.	×	×	×		×	×		×		
,, *contortus*, Ag.					×	×				
,, *compactus*, Owen.		×			×	×				
,, *Sp.* ?								×		
Carcharopsis prototypus, Ag.		×								
Ctenoptychius serratus, Ag.	×				×	×				
,, *Sp. nov.*	×				×					
Ctenodus, Sp. ?						×				
Deltodus, Sp. nov.	×					×		×		
Glossodus marginatus, M'Coy.					×	×				
Helodus didymus, Ag.					×	×				
,, *planus*, Ag.	×		×		×	×		×		
,, *mammillaris*, Ag.					×	×		×		
Homocanthus macrodus, M'Coy.		×			×					
,, *Sp.* ?			×		×			×		
Megalichthys Hibbertii, Ag.	×				×	×	×	×		
Orodus cinctus, Ag.				×						
Orocanthus minor, Ag.					×					
Petalodus Hastingsiæ, Owen.	×	×	×	×	×	×	×			×
Petalorhynchus, Sp. nov.			×		×	×				
Physonemus, Sp. ?		×			×					
Pœcilodus obliquus, Ag.	×				×	×	×	×		×
,, *Sp. nov.*	×				×	×	×	×		
,, *Sp. nov.*					×	×				
Psammodus rugosus, Ag.		×	×	×	×	×				
,, *porosus*, Ag.		×	×		×	×				
Rhizodus Hibbertii ? Ag.					×	×		×		
Tomodus convexus, Ag.	×	×	×	×	×	×		×		
Xystrodus, Sp. nov.	×					×				
,, *striatus*, Ag.						×				
Undescribed spine.				×		×				

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V.—*On a* Bed *of* Fine-Grained Indurated Sandstone, *enclosing Rolled Pebbles of Quartzite, interstratified with the Trap of the Campsie Fells.* By John Young, F.G.S., *Vice-President.*

[Read 15th January, 1874.]

It is now many years since, in my rambles amongst the trap rocks of the Campsie Fells, I became acquainted with the peculiar masses of rock which form the subject of the present communication. In my paper "On the Geology of the Campsie District," I purposely omitted all reference to them, hoping to be able at some time to discover whether or not the rock belonged to the hill, and if so, to find its outcrop. Other duties, however, for a long time prevented me from continuing the investigation, though the subject frequently occurred to my memory; and since the discovery of beds of coal and other strata, with plants and fish-remains of Carboniferous age, intercalated with the traps of the Kilpatrick Hills, recorded in the *Transactions* of the Society,* the importance of finding evidence of interbedded strata at other points in the trap of the Lennox range of hills became the more apparent.

The tract of hill-side on which I first discovered the rock in question, lies to the north-west of the village of Lennoxtown, below a lofty precipice of trap known as the "Black Craig." Underneath this precipice a long slope of the hill is covered with debris and large masses of rock that have fallen from the cliffs above. These strew the hill-side as far down as the road leading from Campsie to Fintry. If the hill be ascended from this point, a little to the east of the present march-dyke, until we come to the old "Crow Road"—an old and now disused car-road that formerly crossed the face of the hill to Fintry at a higher level than the present road—several masses of the rock enclosing pebbles of quartzite will be found.

From this point upwards on the hill-side, the boulders may be traced in increasing numbers, until we arrive at the bottom of the hollow in the eastern side of the "Black Craig," where they are lost, or become covered with the trap debris. This point is

* See Vol. II. p. 149; Vol. IV. p. 77, and p. 123.

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about 900 feet above sea level, and about 650 above the level of the Campsie valley. At higher levels than 900 feet, I have always failed to trace the rock; and from this circumstance I concluded that the masses did not fall from higher portions of the hill, but were probably derived from the outcrop of some intercalated bed now concealed from view.

Being in the district this last autumn, I made a short excursion along the hill-side to the east of the "Black Craig," for the purpose of ascertaining if any trace of the indurated sandstone could be found in that direction. Keeping on the 900 feet level, where I formerly lost all trace of the rock, I was fortunate in again finding it at several points. Nowhere can I say that I saw the bed exactly *in situ*, but from the numerous blocks of the rock which I met with along this level, either lying loose upon the hill-side, or partially imbedded in the soil, I felt convinced that I was on the line of its outcrop. After tracing it for some distance to the eastward, in the direction of Sloughmucklock, I again lost sight of it, owing to the smooth and verdure-covered slope of the hill concealing the underlying beds. The base of the hill for some distance below the indurated sandstone is composed of bedded trap. In Campsie Glen, about half a mile to the westward, these traps are seen to rest upon members of the Ballagan limestone series, while to the eastward of the "Black Craig" the trap is flanked by the lower Carboniferous limestone strata of the Campsie valley.

From an examination of some of the largest blocks of the indurated sandstone that lie upon the hill-side, the bed seems to average from 2½ to 3 feet in thickness. It is in contact above and below with beds of a fine grained dolerite, which in transparent sections prepared for the microscope shew numerous small dark-green crystals of a mineral, probably either of augite or hornblende, and minute grains of iron in a base of felspar.

The colour of the sandstone is a blackish-grey, varying in some blocks to a brownish-grey. The contained pebbles, which are all quartzite, are of a light-grey or white colour. The rock as it lies on the hill-side under its coating of lichens, is not to be distinguished from the trap of the hill by any peculiarity in its colour, and might readily be passed by, but for the quartz pebbles that are occasionally to be seen protruding from the matrix. The stratum differs, however, from an ordinary conglomerate in this respect, that the pebbles, varying in size from

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2 to upwards of 6 inches in diameter, occur only at intervals in the enclosing matrix, which is fine-grained and highly siliceous, there being no grit nor smaller stones filling up the spaces between, as in ordinary conglomerates.

The pebbles, which form the characteristic feature of the bed, are all well rounded and water-worn. In most cases they come quite readily, and with a smooth surface, out of the enclosing matrix. It is evident that the bed must have been deposited in water, as a stratum of fine-grained sand over the surface of the underlying trap; but how the rounded pebbles came to be transported into it at intervals from their parent district, is a point not very easy of explanation. They appear to have been dropped into the sand only here and there, and not to have been drifted by currents of water into their present position. My reasons for coming to this conclusion are that the matrix, as formerly stated, is a very fine grained deposit, and any current that had the power to carry forward pebbles of the size indicated, could not have failed to transport from the same region coarse sand, gravel, and smaller stones; but these we have seen are awanting. The bed therefore differs from the type of an ordinary conglomerate, in which we find stones of various sizes, down to gravel and sand, entering into its composition. As already stated, the stones in the bed are seen to be well rolled; this, I think, it is evident, could only have been done before they were carried to their present position. By what agent they were carried, I will not presume to indicate, beyond stating that water plants when torn up by storms from the stations on which they grew, sometimes enclose water-worn stones amongst their roots, and that these are often drifted away to other tracts where fine sediments are being laid down. This agency has been credited with the carrying of isolated stones met with in other of the geological formations, and it is certain the phenomenon of plants carrying stones over the flat sandy reaches within our own estuary of the Clyde is quite a common occurrence.

If plants carried the stones in this instance, no trace of their remains are now to be found in the bed, nor have I found any fossil evidence to shew whether the stratum is of fresh water or marine origin. I have also broken up several of the quartzite pebbles, and they likewise contain no trace of fossils.

It has been already stated, that the bed under notice lies in the midst of the traps of the hill at an elevation of 900 feet

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above sea level. As the hill at this point rises to the height of 1,500 feet, it follows that at least 600 feet of bedded traps lie over it.

These igneous rocks were no doubt the agents which so highly indurated the stratum from its normal condition of a sandstone, and which would also further vitrify the enclosed pebbles, so that now they cannot be distinguished in hardness and structure from the most vitreous Highland quartzites of Silurian age.

The stratum of sandstone is probably of lower Carboniferous age, like those beds that lie on nearly a similar horizon in the trap of the Kilpatrick Hills to the west. It has evidently been deposited in a basin of the trap, and is probably a lenticular stratum of no great horizontal extent; but from what region the pebbles of quartzite and the arenaceous deposit forming the matrix were derived, it is now impossible to say. From the composition of the materials forming the bed, and the apparent absence of pebbles of trap in the deposit, it is evident the surrounding trap was not then exposed to denudation. We are also entirely ignorant of what may have then been the physical features of the district; indeed all we know is that the Ballagan strata and the traps which form the base of these hills were laid down ere the bed in question was deposited; and that like those already noted in the Kilpatrick Hills, it marks one of those periods of repose between the great outbursts of igneous rock-matter, of which the Campsie Fells are principally built up.

NOTE.—A suite of specimens of the pebbles, matrix, and contiguous trap, were exhibited to afford members an opportunity of studying the peculiarities of the bed. These I purpose placing in the Hunterian Museum, where they may afterwards be consulted along with those obtained from the trap of the Kilpatrick Hills at Bowling.—J. Y.

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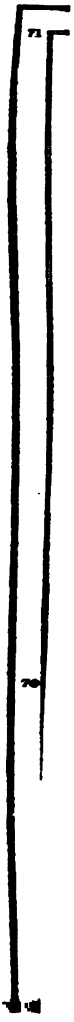

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VI.—Geological Notes *on the* Noursoak Peninsula, Disco Island, *and the country in the vicinity of Disco Bay, North Greenland.* By Robert Brown, of Campster, M.A., Dr. Phil., F.L.S., F.R.G.S., &c., Honorary Associate.

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I.—History of Geological Discovery in Greenland.

I do not think that I can more fitly preface these notes on the lithology of Mid Greenland,* than by briefly sketching the history of the progress of geological discovery in that country. Discovered by a roving Icelandic Viking in the ninth century, it is still very partially known, and it was not until the beginning of this century that we obtained any correct information regarding

* Greenland is divided by the Danish government, who maintain a monopoly of the trade up to 73° N. lat., for the purposes of government, into the north and southern Inspectorates—the former embracing all the coast line north of lat. 66°, the latter all south of that parallel. The region I am describing may be termed Middle Greenland, as it lies between the parallels of 68° 30′ and 71° N. lat.

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its mineral resources or geological history, the early missionaries Egede, Crantz,* Fabricius, and Saabye, as well as other visitors and explorers, being apparently unacquainted with and very little observant of geological phenomena—a branch of science, in truth, but of very recent growth at the period they wrote.

1. *Giesecke.*—Sir Charles Louis Giesecke is famous in the annals of Greenland research more from what he was known to have done, than from what he gave to the world as the fruits of his long labours. He was, however, the first in point of time—if not of merit—of all the Greenland geologists. Born at Augsburg in 1761, he was originally intended for the church; but after various changes of occupation and a life of some adventure—figuring among other *roles* as an actor—he devoted himself in about his fortieth year to mineralogy, and in 1801 studied under the celebrated Werner at the Mining School of Friburg, became "Bergsmand," and finally settled down as a dealer in minerals in Vienna. He subsequently travelled with mineralogical views in several parts of the north of Europe. Eventually entering the service of Denmark, he repaired to Greenland, leaving at Copenhagen a valuable collection of books and minerals, which were destroyed during the bombardment of that city. In the meantime, in Greenland he formed acquisitions of great interest in various departments of natural history; but foreseeing the probability of their capture on the passage to Europe, he with great resolution and perseverance went a second time over the ground he had examined, and remained in the country until his object was accomplished. In the meantime, the vessel which contained his first treasures was captured by the English cruisers and sold by auction at Leith. The minerals attracted but little general notice, in part from their being packed in moss and sea-weed, and perhaps also from the very circumstance of many of the species being unknown.† Most of the collection was purchased by Mr. Allan, who found such a mass of duplicates that nearly all of the cabinets of England were supplied with the rare or new species it contained—sodalite, allanite, cryolite, &c. In 1813 Giesecke himself accidentally arrived in Leith, and considering how mortified he must have been to find the labours of so long a period just departed from under the hammer into cabinets never

* Crantz indeed gives a list of twenty-five minerals collected by Hr. Brasen, a surgeon, who visited that country.

† Greenough, Presidential Address in *Proc. Geol. Soc.*, vol. ii., p. 46.

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intended for their reception, unless through a process different from that which they had undergone, he with great good nature contributed to the improved descriptions and catalogues of the species which subsequently appeared.

Following the Duke of Marlborough's maxim of "quartering himself on the enemy," he obtained the easy post of Professor of Mineralogy to the Royal Dublin Society, and went to reside in Ireland, where he passed the remainder of his days, dying at Dublin in March 1833, at the age of seventy-two. The energy which had distinguished his youth to a great extent evaporated after his return from Greenland, and accordingly he published but little in reference to that country. In addition to a couple of notices relating to Irish minerals,* he wrote the article "Greenland" in Brewster's *Edinburgh Encyclopædia*—an article which yet forms one of the best accounts of Greenland in the English language. His meteorological observations were published in the *Edinburgh Philosophical Journal* for 1818, and Dr. Scoresby obtained the use of his maps and other materials for his *Voyage to Greenland*, which contains also an interesting letter from him on the structure of Greenland, containing views almost identical with those which later research has constrained me to advocate in another place.† His rich collection of minerals was never arranged, and, I am informed, lie even yet in the Dublin Society's museum practically useless from the displacement of the labels. In the *Edinburgh Philosophical Journal* for 1822 he gave an account of the geological conditions of cryolite —the original specimens discovered by him being now in the Edinburgh Museum of Science and Art, having been obtained from the Allan purchase of Giesecke's first collection. In the *Transactions of the Royal Society of Edinburgh*‡ is a short but interesting paper by him on the "Mineralogy of Disco Island," with maps and several views of scenery. These comprehended the extent of his literary contributions, though he had always intended writing an extensive work on Greenland, the value of which I need scarcely say would have been immense. During the whole of his residence in Greenland he kept the most minute diary of his labours. This journal is now in Copenhagen, and a

* *Annals of Philosophy*, 1825 and 1826, reprinted from *The Dublin Philosophical Journal.*

† *Quart. Journal Geol. Soc.*, Feb. 1871.

‡ Vol. ix., pp. 264-272.

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copy is in the possession of the Royal Dublin Society. Mr. R. H. Scott, of the Meteorological Office in London, was good enough to copy several extracts for our use, and I cannot but recollect how minutely accurate was every particular, though at the same time it was mainly mineralogical, and therefore of little value to us. He was a knight of the Danish order of Dannebrog —hence the title he is known by in England. Sir Charles Giesecke's reputation deserves embalming in any history of geological research in Greenland, for he was the first and the most enthusiastic of all those who have visited it for scientific purposes.

2. *Pingel.*—In 1828 the Danish government despatched Lieut. Graah on an expedition, the object of which was to endeavour to trace out the fate of the lost Icelandic colonies. This work he performed with a zeal and heroism that has long obtained for that officer—only lately deceased—the admiration of all geographers and antiquaries;* but we are more particularly interested in knowing that he was accompanied as far as the South-western coast by Dr. Pingel, an excellent geologist, who unfortunately was too soon lost to the science he was so well qualified to advance. He was fortunate enough to discover the "Red Sandstone of Igalliko," and to draw attention to the remarkable subsidence of the Greenland coast going on—a subject of extreme interest, and which, owing to his description,† has since attracted much attention, but, as I have ventured to shew in another place,‡ has been somewhat misunderstood.

3. *Rink.*—Little or nothing was added to our knowledge of the geology of Greenland until more than twenty years ago Dr. Heinrich Rink, who had previously distinguished himself as one of the naturalists of the Royal Danish ship "Galatea," under her voyage round the world, under Steen-Bille, paid an extended visit to Greenland for the purpose of making geological surveys. These explorations were extended over the long subsequent period during which he resided in the country as "Inspector" or Governor of South Greenland, but his results were given to the world in 1852, in a valuable memoir, published by the Royal

* *Undersögelses-Reise til Östkysten af Grönland*, efter Kongl. Befaling udfört i Aarene, 1828-31. (Also trans. into English by Mr. Macdougall, R.N.)

† *Proceedings of the Geological Society of London*, vol. ii.

‡ *Transactions of the British Association for the Advancement of Science*, 1869; and *Quart. Journ. Geol. Soc.*, 1871.

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Danish Academy of Sciences.* He has recently (1868) returned from Greenland (and is now Director of the Greenland Commerce), but, with the exception of occasional short papers,† his time has since then been occupied with the study of the physical geography and ethnology of the country, which he has long governed with benefit to the aborigines and satisfaction to his sovereign and country. His memoir mentioned is mainly occupied with the mineralogy of the country, and the physical effects of the glacier and inland ice in altering the climate and scenery of the country, but he for the first time has clearly laid down and mapped out the geognosy of the country. His standard work‡ will long be the main authority for our knowledge of the structure and resources of Danish Greenland.

4. *Later Explorers.*—Between 1850 and 1867 numerous exploring expeditions, either in search of Sir John Franklin's party or for geographical discovery, passed along the coast of Greenland, touching here and there at various points, or even wintering on the northern part of the country. In addition to this many whalers had before and have after this period also visited the coast; but neither the officers of the government nor whaling vessels added much to our knowledge of Greenland geology. In the narratives which some of them published will be found various stray notices on this subject, but even when these remarks are not the result of the most hasty observation and generalisation, few of them added anything to our former information derived from sources more capable and trustworthy. I do not suppose, therefore, that it is necessary for me to refer at any length to the results of these voyages further than by remarking that the narratives of the voyages of Penny and Sutherland, Inglefield, Kane, and Hayes are the only ones in which any information on this topic worthy of remark will be found. However, about this period the discovery of the economic importance of the cryolite veins in South Greenland led to an increased knowledge of the mineralogy of those sec-

* *Om den geographiske Beskaffenhed af de danske Handels-distrikter i Nordgrönland:* Udsigt over Nordgrönlands Geognosie (Det Kongl. danske Videnak. Selskab. Sk., 3 Bind, 1853, p. 71.) In all, Dr. Rink resided twenty-three summers and eighteen winters in Greenland.

† *Journal of the Royal Geographical Society*, vol. xxiii. and vol. xxviii.; *Naturhistoriske Tidsskrift* (3rd series), 1852, &c.

‡ *Grönland Geographiske og Statistisk beskrevet.* 2 vols.; and *Eskimoiske Eventyr og Sagn overnatte efter de Infödte fortælleres opskrifter og Meddelelser.*

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tions of the country, and the researches of the late Chevalier, Justitsraad C. S. M. Olrik, for many years the Royal Inspector of North Greenland, and latterly Director of the Greenland Trade in Copenhagen, added not a little to our knowledge of the palæontology of the miocene beds. This I shall immediately have occasion to refer to, as well as to our expedition to the country in the summer of 1867, of which these notes are the narrative. During the summer of 1870 the eminent Swedish naturalists MM. Nordenskjöld, Berggren, Nordström, and Oberg visited Greenland, and went over a considerable portion of our ground. Their observations* are exceedingly interesting, although in some cases I may have to differ from them. Owing to the non-publication of my notes† I have in many cases lost the priority of discovery. This is, however, a trifling matter, and one entirely personal. It is, however, a source of pleasure to see that in most cases they have confirmed my observations, and where published have noted this fact most conscientiously. I shall have occasion to refer to their observations as we pass along. In 1872 Dhrr. J. G. Rohde and K. J. V. Steenstrup (nephew of the celebrated Danish naturalist of that name) also visited Mid Greenland, making some observations‡ which I have incorporated into the map accompanying this paper. Until recently the only information we possessed in regard to the geology of East Greenland was in the shape of a few fragments of notices of a very vague character in Scoresby's *Voyage to East Greenland.* The researches of the German expedition to that region have, however, added considerably to our knowledge, as I will have occasion to notice when speaking of the range of the miocene beds.

II.—General Geology of Greenland.

1. *Primitive and Metamorphic Rocks.*—These are chiefly gneiss, mica-schist, hornblende-schist, syenite, &c., pierced by granitic veins, and are the most widely distributed of all the Greenland

* *Redogörelse jör en Expedition till Grönland Ar* 1870, af A. E. Nordenskjöld (Oversigt af K. Vet-Akad, förh. 1870, No. 10, and as a separate publication, Stockholm, 1871). It has been translated, apparently by Professor Nordenskjold himself, in *The Geological Magazine*, July, August, September, October, and November, 1872.

† In the hope that they might be incorporated in a general work on the Expedition by my companions and myself.

‡ Petermann's *Geographische Mittheilungen*, 1874, p. 142.

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formations, extending from the extreme north to the south of Greenland, with the exception of a few patches occupied by traps and miocene beds and the Igalliko Sandstone. They reach to 4000 feet in height, and form the rock almost everywhere seen protruding from beneath the "inland" or continental ice which covers the interior of the country. The aspects of the country occupied by this rock are, rounded bosses of hills, ice-planed, with mossy valleys, or glaciers protruding to the sea. Rarely does it form the jagged peaks and more varied scenery of the trap rocks, though sometimes rising into high hills.

In this formation are found all the economic minerals of Greenland. The only ones of which are of any economic importance are, steatite, used to make the lamps and other domestic ware of the natives, though this manufacture is greatly on the decrease, and cryolite, a mineral of great and increasing value. The mineral was originally brought to the notice of mineralogists by Giesecke; but it was not until a comparatively recent period, chiefly owing to the energy of Mr. Tayler of London, now of Prince Edward's Island, and the Messrs. Thomsen of Copenhagen, that its value has been properly developed. The mineral derives its name from κρύος, ice, from its property of melting in the flame of a candle. It is a crystalline mineral, varying in colour from snow-white when pure to almost black when mixed with extraneous substances; probably, according to Eriglok, graphite, as the colouring matter disappears when the mineral is heated. In chemical composition it is a double fluoride of sodium and aluminium, and its formula is $Na. Fl.\frac{1}{3} Al.^2 Fl.^3 = \times$ Aluminium, 13·0; Sodium, 32·8; Fluorine, 54·2. It is valuable as an ore of aluminium, for when melted with sodium the metal is liberated from its combination with fluorine, the result being aluminium and fluoride of sodium. It is now exported for this purpose in great quantities to America and Europe—chiefly to the cryolite manufacturers of Copenhagen, where it is applied to a variety of purposes, a description of which would, however, be foreign to the subject of this paper. In 1861 thirty ships were sent from Greenland with cryolite. From a recent report by Mr. Paul Quale, we learn that the chief veins at present worked are situated at Iviktout or Ivigtot on the south side of Arsuk Fjord, in South Greenland, in 61° 13′ N. lat. and 48° 9′ W. long. (Green.) The surface of the vein of cryolite was originally covered with a layer of earth, clay, and gravel, which being

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removed the vein is exposed. Its greatest length is about 600 feet, breadth about 150 feet, and the extent about 53,000 cubic feet. It is composed of two parts, one close to the fjord, the other to the east, and separated by a rock from 5 to 15 feet high and about 100 feet broad. It is contained in gneiss crossed in several parts by veins or layers running from north-west to south. The principal mineral in the vein is of course cryolite, but as constant accompaniments are found quartz, iron-stone, lead ore, sulphate of iron, sulphur, arsenic, and tin-stone, though the last two are very rare. These substances are not evenly distributed through the mass, but the cryolite is partly found quite clean and unmixed, while larger and smaller quantities are found containing more or less of the above-mentioned minerals. A strip of the vein only a few feet broad along the south and south-west boundary of the same is conspicuous for its richness in iron-stone and quartz, but especially for lead ore and sulphate of iron. The surrounding mountain is also in certain places—viz., along the south-western boundary—strongly impregnated with lead ore, copperas, and varieties of arsenic, tantalite, molybdena ore and tin-stone. In the cryolite, according to Mr. Quale, are found pieces of the surrounding rock—both of granite and trap, and it therefore appears that the cryolite is newer than the gneiss and the trap—the melted cryolite having during its progress torn off part of the latter rocks and enclosed them in itself (?). The mine during the winter is filled with ice and snow, and all blasting must therefore cease from the month of November to April. In the summer and autumn months, from May to October, the mine can be worked, except under unusually severe climatic conditions, and in this time, with a gang of about 50 men, about 5000 tons of cryolite can be had. There is considerable difficulty in keeping the workmen in health; but from what I can learn there need be no immediate fear of a failure of the mineral, though its distribution is exceedingly local, being almost entirely confined, except in small quantities, to the fjord mentioned. Excepting a small amount found at Miask, in Siberia, the mineral is confined to Greenland.*

* In addition to the Report quoted (*Smithsonian Report*, 1866) and a Report issued "On the Resources of Iceland and Greenland" by the United States government (1868), for further particulars regarding the geology and economic value of cryolite, we may refer to the work of Rink already mentioned, and the three following works in Danish:—L. Jacobsen's *Et Aar i Grönland*, with sections and plans (1862); E. Bluhme's *Fra et Ophold i Grönland*, 1863-

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Graphite is found in great abundance on some of the islands lying off the Greenland coast, but hitherto it has not been found profitable to export it to Europe.

The basalt or trap extends right across the country north of 69° N. lat., and appears to date from tertiary periods. It is particularly well developed in Disco Island and the Noursoak Peninsula, covering an area of some 7000 square miles, and rising in some places to a height of 6000 feet. Near Disco these trap deposits overlie the gneiss. Properly speaking, the Disco Bay traps are not masses of lava, but "*consolidated beds of ashes and volcanic sand,*" which in time by pressure has assumed a crystalline character, a fact pointed out by Nordenskjöld, but which also struck me during my examination of the same rocks.

In the peculiarly disintegrating climate of Greenland the trap speedily decomposes, and is being rapidly destroyed. With these trap rocks are almost invariably associated the miocene and cretaceous beds.*

2. *The Red Sandstone.*—This was originally discovered and described by Pingel,† and is only found in the fjords of Igalliko and Tunnudleorbik in about 61° N. lat. It is probably Devonian, but owing to the absence of fossils the age of this interesting formation cannot be accurately determined. The rock is for the most part firm and hard in structure, and is composed of fused quartz particles, as if caused by a porphyritic eruption. The whole formation appears to be very local, but perhaps a part is concealed under the continental ice. And here I may remark that the absence or sporadic distri-

1864 (1865), and V. Vallö's *Grönland* (No. xxxiv. of the *Danske Folkeskrifter*, 1861), as well as certain papers by Lieut. Bluhme (of which the above work by him is mainly a reprint), in the Danish magazine *Fra alle Lande*, vol. i. Many details of the chemical and other characteristics of cryolite and its derivative aluminium may be found in numerous reports and communications scattered through various scientific periodicals, by Wohler, H. St. Clair Deville, H. Rose, Bunsen, Charles N. A. Tissier, J. W. Tayler, C. Brunner, Salvétat, Salm-Horstmar, Erdmann, Heeren and Karmarsch, N. Debreeq, Mallet, Baff, H. Masson, Kobell, Bondet, Schötter, Hirzel, Degousse, Fabian, Christofle, Sauerwein, J. Thomsen, Scherer, A. Strange, R. Wagner, Dallo, C. Hegemann, and others. Deville has published a separate work, *De l'Aluminium* (Paris, 1859), and Tissier, a *Guide Pratique de la Fabrication de l'Aluminium.*

* For an excellent description of the basalt of Greenland see Nordenskjöld, *l.c.*

† *Afhand. Videnkab. Selskab. Skrifter*, 1828.

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bution of sedimentary rocks in Greenland appear mainly due to the denudation the country has undergone by ice action, as I shall have occasion to refer to more particularly when speaking of the distribution of the miocene beds.

3. *Carboniferous.*—Though coal has been long known in Greenland, it belongs to a period much more recent than the true carboniferous. In 1870 and 1871, however, the Swedish expedition, as well as my friend Dr. Georg Pfaff, the inspecting surgeon, for many years resident in Greenland, have discovered *Sigillaria*, a *Pecopteris*(?), &c., on the Disco shore at Ujarasasuk. These fossils, probably belonging to the true carboniferous period, have however been as yet only found in travelled blocks, not in rocks *in situ*, so that the existence of the carboniferous formation in Greenland is still problematical. They may have drifted in ice from the carboniferous strata of Melville Island. One of these plants, sent me by Dr. Pfaff, I submitted to the inspection of a very competent authority, my friend Mr. Robert Etheridge, Jun., F.G.S., Palæontologist to the Geological Survey of Scotland. The result of his examination he communicates in the following note:—"The fossil is unfortuuately only a blackened cast of the fern itself, all the vegetable matter having apparently vanished, except along the rachis, where a little carbonised material still remains. Its characters are rendered yet more indistinct from the nature of the matrix—a fine grained grit. The fern appears to be allied to those figured by Heer under the name of *Gleichenia*, *G. Gieseckiana*, Hr., *G. Zippei*, Corda, *G. Rinkiana*, Hr., &c., but I think not identical with any of them; more probably a new species of either *Gleichenia* or *Pecopteris*. The whole of the nervation has disappeared, so that I think it would be somewhat hazardous to describe it as a new species simply on the two specimens in your possession." Agreeing with Mr. Etheridge I have not thought it necessary in the meantime to either describe or figure it, but on receipt of more specimens may do so.*

4. *Cretaceous.*—This formation in Greenland has only been recently separated from the miocene formation, with which it is

* The coal discovered by the German Expedition, on Kuhn Island, East Greenland, appears to be Liassic; but until these strata are fully described in the last volume of the Report of the Expedition, now in the press, it is better to say nothing about them, more especially as I have no personal knowledge of the region, and no formation of that age is yet known to exist in West Greenland.

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associated and was supposed to be a part of. It is, as far as we yet know, only found in the vicinity of Kome or Koke, near the shores of Omenak Fjord, in about 70° N. lat., though traces have been found elsewhere on Disco, &c. The fossils hitherto brought to Europe have been very few, and consist of plants which are now preserved in the Stockholm and Copenhagen Museums. From these there seems little doubt that the age assigned to this limited deposit (so far as we yet know) by the celebrated palæontologist, Professor Oswald Heer of Zurich, is the correct one. Hitherto our knowledge of it is of the most limited and fragmentary character. The British Association, however, at its meeting at Liverpool (September 1870) voted £50 for the investigation of this deposit; and it is to be hoped that this sum, if judiciously expended by some of the intelligent Danish officers resident in the vicinity, will go far to increase the materials at present at our disposal for the study of the cretaceous formation as developed in Greenland.

5. *Miocene.*—This formation (called by Rink* "Trap formation med Kulförende lag"), in West Greenland, is entirely confined to the vicinity of the Waigatz Strait and Omenak Fjord, and is the chief subject of this paper.

6. *Quaternary Deposits.*—These consist of the peats at present slowly in process of formation, and of beds of clay, with scattered boulders, shells, and other marine remains — the exact counterpart of our laminated fossiliferous or brick clays in Scotland. These I have fully described in conjunction with the glaciers and inland ice—which we must consider in the light of a post-tertiary deposit in course of formation—in another place,† so that I need not further refer to them here, but at once proceed to a description of the lithology of the miocene beds.

III.—Notes of a Coasting Voyage to Explore the Miocene Beds of Greenland.

The existence of fossil plants of a very recent date in the strata on the shores of the Waigat Strait was known to Giesecke, and is frequently referred to in his journal, but he seemed to be entirely unaware of their age and significance—

* *Grönland*, vol. ii., app. 136-152.

† *Quarterly Journal of the Geological Society of London* (February, 1871), and "Das Innere der Grönland," Petermann's *Geog. Mittheil.*, 1871.

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supposing them to be identical with or nearly allied to the ordinary *Sorbus aucuparia* and *Angelica officinalis*, a plant now growing on some portions of Disco Island.* It was not until MM. Olrik and Rink had sent some of the specimens to Europe that their nature was apprehended. Subsequently through the exertions of Captain (now Admiral) Inglefield, R.N., Dr. Lyall, R. N., and Dr. David Walker of the "Fox" expedition—aided by M. Olrik, several specimens reached England, and these with those already in Copenhagen Museum were, with the other Arctic plants, described in Professor Heer's very important work, *Flora Fossilis Arctica* (1867). A general resumé of his results are also given by him in the *Journal of the Royal Dublin Society* for 1867.† In the autumn of that year the British Association voted a sum of money—subsequently increased by contributions from the Government Grant Fund of the Royal Society to £300—to a committee formed for the purposes of investigating this flora more fully, and several members of this committee proposed to go to Greenland during the ensuing summer with that object in view. Various circumstances having, however, prevented that project from being carried into effect, the money was handed over to Mr. Edward Whymper, an English artist who had proposed visiting Greenland for other purposes. Arriving in England from America about that period, I was invited by that gentleman to take part in the expedition, my share of the duties being that of geologist, botanist, zoologist, and astronomical observer. I had previously visited the coast as early as 1861. Subsequently Mr. Anthon Peder Tegner of Copenhagen, who had passed several years in Greenland, joined the expedition at Copenhagen, and in addition to several Eskimo, two Danes—Mr. Jens Fleischer (son of the Governor of Jakobshavn, our headquarters) and Carl Emil Olsen, a "sailor" in the service of the Government, attached themselves to the expedition for limited periods. They however took no share in the collection of the fossils, having left our party before that portion of our work commenced; but I found Mr. Tegner a very intelligent and active assistant, and I take this fitting opportunity to publicly record my thanks to him for his assistance in the more mechanical work of my geological

* See my "Florula Discoana," Introduction—*Trans. Bot. Soc. Edin.*, vol. ix.

† Vol. v. (No. xxxvi.), p. 84.

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duty, as I have already elsewhere * done to him for assistance in zoological collection. Mr. E. Whymper (a brother of my former excellent friend and companion, Mr. Fred. Whymper, now of San Francisco), though unable to assist in my scientific duties, was most indefatigable in preserving our collections, and to his care and assiduity in managing such matters may be attributed the very excellent condition in which they arrived in London after their long and stormy voyage of several days in small boats to Godhavn, from thence six weeks to Copenhagen, in addition to their transit from London to Zurich and back again. We arrived in Greenland by one of the royal ships from Copenhagen on the 7th of June, but it was not until the middle of August that we found leisure to visit the Waigat Strait, just before returning to Europe. Our proceedings there, I propose to record in the following notes. They are mainly transcripts from my journals and notes written on the spot, and were communicated in short abstract to Professor Heer, who described our plants, and published by that gentleman in his descriptive memoir in the *Philosophical Transactions* for 1869.† Owing to limited space and my not having had an opportunity of revising the proof, these notes published by Professor Heer are not so complete nor so accurately printed as would have been desirable. However, the elucidation of my fossil collection by Dr. Heer has

* *Proceedings of the Zoological Society of London*, 1868 ("Mammals of Greenland," "Pinnepedia frequenting the Greenland and Spitzbergen Seas," and "Cetacea of the Greenland Seas"; also translated in Petermann's *Geog. Mitt.*, 1869).

† Owing to an awkward mistake, the title of Professor Heer's paper in *The Philosophical Transactions* entirely misrepresents to whom the credit of making a collection, which has been considered of sufficient importance to be made and published under such distinguished auspices, is due. I have been requested to publish the following most authoritative statement on the subject. In August 1870 I addressed, at the instance of those who felt annoyed at the somewhat unnecessarily dogmatic title of the paper in question, the following note to Mr. Anth. P. Tegner, surgeon, who had since his return to Europe been residing in Iceland, and had therefore been hitherto difficult to be communicated with:—"Dear Sir—Would you, as the only one of our companions of the Greenland Expedition of 1869 in Europe, kindly inform to whom the botanical, zoological, and *geological* collections and observations made in that expedition were due. An answer would oblige, yours faithfully, Rob. Brown." "Aug. 31st. Dear Sir,—In answer to your note, I have much pleasure in saying that the *whole* of the scientific collections and observations made in Greenland in 1867 were made by you. I assisted you in the collection of the animals and fossils, as acknowledged by you in your published writings. I am, dear sir, yours faithfully, Anth. Tegner."

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enabled me to present these field notes more fully than would otherwise have been possible. If they should present in some way a similarity to another outline report of the expedition already published, the explanation must be that they relate to the same expedition, and that my journals were lent for some time to the author of that report, in order to extract what he might consider desirable. It will, however, be found that these notes are to a great extent original, and as giving the first extended account of the stratification of these important deposits, may be of some use to geologists at home, or to future collectors who will doubtless visit these deposits. After careful consideration, I think that the most instructive way in which I can present them will be to give the notes in the chronological order in which they were taken, merely copying them as written in my journal of each day's date. Though this method may lack the stateliness—not to mention the dulness and slight obscurity—supposed by some to be necessary in a scientific document, yet I believe that what it would gain in ponderosity by adopting a more strictly scientific systematic arrangement, it would lose in clearness and intelligibility. As these two qualities are what I aim at in this paper, I will proceed to give a narrative of our operations, omitting as far as possible all extraneous matter and all the personal adventures which such an expedition, undertaken on the eve of an Arctic winter in 70° north latitude, could not fail to abundantly supply. My botanical and zoological observations have been, to a great extent, already published elsewhere.*

1. *Atanakerdluk*, Lat. 70° 02′ 30″ N. (by my observations, Nordenskjöld's exactly agreeing), Long. 52° 15′ 3″ W.—The only rocks which present themselves on the shores of the mainland of Disco Bay coasting from Jakobshavn † (our headquarters) to this locality, are the primitive formations (gneiss) already described. They sometimes rise into hills 1400 feet in height, but the general aspect of the country is low rounded hills interspersed with mossy valleys, the hills covered with travelled blocks and boulders, and smoothed and polished by ice action. The rocks are bare, except where covered with a mossy covering of

* *Trans. Bot. Soc.*, vol. ix., x., &c.; Lauder Lindsay, *Trans. Linn. Soc.*, 1870, *Proc. Zool. Soc.*, *l.c.*, *&c.*

† According to my observations in lat. 69° 13′ 26″ N. (long. 50° 55′ 30″ W. of Greenwich).

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lichens, while here and there, over places where a peaty soil has accumulated, the Arctic birch (*Betula nana*), willow (*Salix*, various species), *Andromeda*, *Vaccinum* or Crowberry (*Empetrum*) creep in such unwonted profusion that in the height of summer some more favoured spots seem almost to support the florid title which Erik Ranthri gave to the country he was the first European to land on. Everywhere—in and about and over all—the dreary marks of present or former ice action are apparent. Looking down from the hills the eye is chilled in the height of an Arctic summer by a dismal little lake with the ice yet unbroken on the surface, or a little glacier creeping its slow way down to the sea, while beyond all stretches the great "inland ice" which covers Greenland like a winding-sheet in its icy pall, north and south, east and west, far as the eye can see, or the observation of the few explorers who have attempted to penetrate it have enabled us to judge; while out in the bay in front, the view of the opposite island of Disco is obscured by the fleet of icebergs which have poured out of the great ice fjord which lies between us and Claushavn, a pleasant little outpost which contains our nearest neighbours. Such was the view which morning after morning and night after night—for we had a long day of more than two months when the sun never set, and we often turned night into day in our scientific excursions—greeted our eyes. It was not until the morning of August 19, that we bid good-bye to Jakobshavn, at the summons of Jens Jebbisen the captain of the blubber boat which is deputed to convey us to Ritenbenk, the post nearest to the miocene deposits, at which we propose working for the rest of our stay in Greenland. We take coffee with the hyperborean aristocracy, and shake hands with and say "far-vel!" to the assembled 'οἱ πολλοί, who line the shore to see the sojourners from a far-off land bid good-bye, most likely for ever, to what had been their temporary home for so long, and a long plaintive "far-vel!" comes wafting after us, as we scud before the breeze and leave the ancient and seal-like odour of Ilulissat (Jakobshavn), its kindly little fur-clad inhabitants, and our hospitable Danish friends, behind us. We sail along a low-lying gneissose coast line backed by higher fells, and with pleasant-looking birch-clothed valleys with large moraines—remains of former glaciers which have now retreated, only again to form and fill up these valleys, as slowly and surely

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the overflow of the inland ice must find its way through these glacier-filled valleys to the sea, there to be discharged in icebergs, there again to be melted, rise in vapour, and fall in snow, the surplus of which will again go to form the feeding material of this huge "store of ice and snow," and again repeat the cycle of ages gone by. By evening we pass Klokkerhuk, a deserted port, but where a house still stands, once a considerable post, presided over by an assistant, for the prosecution of the whale fishery—a branch of industry now nearly extinct in Disco Bay. By moonlight we arrive at Akpaet * (Ritenbenk, Lat. 69° 45′ 34″ N., Long. 51° 7′ W.), and are warmly welcomed by Herr and Fru Andersen, the Danish residents, who put every convenience in their power to enable us to prosecute our plans, and cause us to ever remember Ritenbenk as a pleasant oasis in the dreary desert around. Ritenbenk is built on a gneissose islet, but yet close behind the colonibestyrer's house I saw a spur of trap, which also appears on the opposite mainland (or more properly on the Arve Prince's Island). This was the first trap we had seen, though farther to the south (between 62° and 63°) primitive trap shews itself on the islands. With intervals the tertiary traps continue to nearly 76° north latitude. Northward to Sakkak, which is our next halting place, we see nothing but the same granitic rocks, which give a light varied appearance to the country compared with the gloomy dark trap spurs which give a character to the country to the northward. On our way we halted in a bay called, as many places in the country are, Niakonak, where are the ruined abodes of some former Eskimo settlement. Here Mr. Whymper gathered some of the old implements and flint arrowpoints found everywhere so abundantly in the old graves and houses in Greenland. Sakkak is a small outpost presided over by Mr. Udligger Sören Jensen, who has been here for 25 years (ever since the chief settlement was removed from here to Ritenbenk—hence Sakkak is called Gammél ("old") Ritenbenk)—and is, as might be expected under the circumstances, perfectly contented with his lot. The whole sea around here was covered with icebergs, and the shore was strewed with fragments which the dogs were eagerly biting to allay the thirst generated by banquets of the entrails of seals, numbers of which are caught here, and were lying on the shore. Over the cliff behind the settlement, the

* Written "Agpaat" in Kleinschmidt's Eskimo map of Greenland ("Sinerissap Kavdlunâkarfiligtâ").

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inland ice was peeping in a miniature "hanging glacier," and on one of the bergs was a huge block of stone, apparently trap, which at first sight appeared like a house built on a snow-covered island. Most of these bergs seem to have drifted east from the Tossukateks ice-stream, though some may have come from the Jakobshavn ice-stream, from the Great Kangerdluisoak, Innerit, Itilfliarsuk, Sermelik, Little Kariak, and Great Kariak ice-streams on the other side of the Noursoak Peninsula. We had now fairly entered the Waigat of the English whaler, the Waygatz of the old Dutch, whose chief whaling ground was in Disco Bay, Waigattet of the Danes, and the Ikareseksoak of the native Greenlanders, and about one o'clock on the morning of the 22nd August we arrived with a number of Eskimo—male and female—who had joined us at Ritenbenk and Sakkak as guides and rowers for our two boats. Here the country had all changed since yesterday. Instead of the open sunny slopes and round granitic knolls to the water's edge, the shore was lined by a strip of sandy beach backed by trap cliffs, rising here to the height of 3000 or 4000 feet, and on the other side, according to Rink's map, to the height of even 6000 feet, while in white transverse streaks in the cliffs the miocene strata, which now appear for the first, give a varied appearance to the scenery. We at once proceeded to the locality at Atanakerdluk where former observers had obtained the fossils, and found it on a sloping bank, a little more than 1100 feet perpendicular above the sea.* Here the strata have been denuded and disintegrated by the action of the weather and of the spring torrents, which must pour from the melting snow on the summits above. Everywhere the slope was deeply cut into ravines by these streams, and though the exposure was sunny and the soil more plentiful than is usual in Greenland, yet the sweep of the melting snow had left but little chance of plants taking root, and but few were seen, and these of a character different from the flora of the gneiss formations farther to the south. Beyond the appearance of a few sea-fowl and the sound of the bell-like croak of the raven (*Corvus corax*, Linn.) hovering over some native fishing huts at the point, the never-failing seals were the only signs or sounds of animated life to be seen. A reindeer had been killed at Sakkak a few days before our arrival, but this animal is now almost extinct in the vicinity of Disco

* According to the mean of three different sets of observations by Colomb, Whymper, and Nordenskjöld, 1154 feet.

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Bay and altogether on Disco Island, where it was so abundant in the days of Crantz and Fabricius. A *Coccinella trifasciata* basking in the sun on a piece of rock was the solitary representative of the insect life which once sported in the ancient forest we were engaged in disentombing from the rocks beneath our feet. The fossils were lying scattered about on a flat place near the edge of a deep ravine (or, as it would be called in California, a "gulch," or in Australia, a "gully") down which a creek, called "Ekadluk,"* courses to the Waigat Strait, laying open an excellent section, of which anon. The fragments of rock—a description of siderite—in which the fossil impressions are here almost invariably preserved, appear to be the only species of rock which, being harder than the seams of shale and sandstone alternating with it in the original bedding of the strata, had survived their disintegration. Accordingly, although originally in thin beds, this siderite being very fragile is now seen in pieces varying from a couple of feet square to mere fragments washed down from the original strata, and buried in the debris of sandstone and shale which had been arrested on this flat spot (though pieces are found all the way down the slope), and got converted in a soil bearing the appearance of a pseudo-stratification, partly owing to the depositing power of the flood which brought it down, and partly to the accidental order in which the soft rock (sandstones and shales) of which it is composed happened to be deposited. I need hardly say, however, that this bedding has nothing whatever to do with the stratification or order of superposition of the rocks in which the fossils are now alone found, and that the laborious section of the soil in which the pieces happen to be accidentally strewed is not of the slightest value or use, as those rocks are not *in situ*. Leaving Mr. Tegner for part of the next two days to superintend the grubbing out by the natives of the fossils embedded in this clay, I made a section, as carefully as time and circumstances would admit, of the whole slope along the section exposed by the course of the stream, which was now very small, but must during the spring and early summer months be a wild mountain torrent sweeping everything before it.

* This is probably connected with the name of Atanakerdluk, which again means the rocks in the sea—some basalt rocks lying in a skerry off here. I used the word *creek* in the American sense to express a rivulet or burn (*Scottice*)—not an inlet of the sea, as used by naval surveyors.

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(*a*.) *Section along the Course of the Creek at Atanakerdluk: General Strike of the Strata E.N.E., Dip as noted.*

1. 6 feet (?) sandstone, medium grained, dip 32°.*
2. Shaly coal (?), 10 inches.
3. Seam of lignitic coal, 14 inches.
4. Shale with faint vegetable impressions, 16 inches.
5. Hard clayey shale, broken into splintery angular pieces, 10 inches.
6. 20 feet black shale, faint vegetable impressions.
7. 16 feet fine grained sandstone, with brownish specks (iron?), dip 26°.
8. Soft shaly seam, interstratified with sandstone in thin scaly layers, 6 inches.
9. 6 inches of sandstone in scaly layers.
10. 1 inch shale.
11. 18 inches fine white sandstone.
12. 8 inches soft shale.
13. 11 inches slaty coal, dip 28°.
14. Soft black clay slates, 3 feet.
15. Soft white sandstone, 3 feet.
16. 4 inches soft black splintery shales.
17. 2½ feet hard sandstone.
18. 3 feet white sandstone.
19. 2½ feet bed of splintery shale.
20. 10 inches of soft sandstone shale.
21. 4 feet splintery shale, rather indistinct, as at this spot the section is hidden by debris from the cliff above.
22. White soft sandstone, medium grained, 3 feet.
23. Splintery shales, 6 feet.
24. Fine grained brownish sandstone, 5 feet. Dip 27½°.
25. Shaly beds, intermixed with a few small fragmentary layers of sandstone and hard shale; but at this place the section is indistinct, being covered with debris. I estimated the depth of these beds to be 150 feet, but it is almost unnecessary to say that the depth of all the great beds is only an approximately accurate estimate.

* What this sandstone rested on, or if this was the whole extent of its thickness, I could not be certain, as it was concealed by the debris brought down by the creek. Most likely it rested on trap.

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26. 4 feet white sandstone.
27. 60 feet splintery (?) shale.
28. 5 feet white sandstone, dip 43°.
29. 8 feet shale.
30. 16 feet brown sandstone.
31. 3 feet soft hard shales.
32. 5 feet white sandstone.
33. 28 feet black splintery shales.
34. 4 feet harder shales.
35. (?) brown sandstone.

This brown sandstone I could see exposed here and there, but the section at this place for a perpendicular height of about 150 feet became concealed by debris, so that I can only state this portion provisionally.

36. At this place a seam of white sandstone was exposed in either cliff, depth about 30 feet as far as could be seen. Dip 40°. Here a dyke of trap intersected the beds right across the creek to the other bank, and could be seen cutting across the strata in a course N. 43° E. Mag., standing out in bare exposed wall-like masses of an average breadth of 12 feet, and the angle at which it appears in the strata was about 5°. This dyke I mark "A."

37. Between the last bed and the trap was a mass of debris concealing the section, but to all appearance the bed was in contact with the igneous rock throughout. The rock was a brownish sandstone, 8 feet in thickness. Dip as above. I examined where this sandstone came in contact with the trap, but the metamorphosis was little. In some cases the sandstone enclosed small pieces of the trap. What does this mean? This brown sandstone has altogether, on either side of the dyke, an average thickness throughout of 30 feet.

38. Here on the opposite (southerly) side of the creek were several feet of shales interbedded within seams of coal and sandstone, exposed. I could not trace them on the northerly side for debris.

39. Hard fine sandstone, 3 feet.
40. Soft crumbling shales, 16 feet.
41. α. Thin seam of sandstone.
    β. Scaly sandstone, with black shales.
    γ. Thin layer of sandstone.
    δ. Laminated sandstone.

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s. Layers of sandstone.

t. Irregular bed of black shale, very thin. All the seams enumerated above are mere layers, but are tolerably distinct.

42. The section here becomes a little indistinct, but shews about 40 feet of gritty sandstone (white), with brownish (iron?) stains at the lower portion, and intermixed with an irregular seam of conglomerate. Dip 27°.

43. Reddish sandstone, but difficult to say if distinct from the last (42). On this I found an alkaline efflorescence, apparently the same as the "alkali" of the American wastes near the Rocky Mountains.

44. 40 feet clayey splintery shales.

45. 3 feet greyish sandstone, tinged with specks of oxide of iron.

46. Black splintery shale, of small depth.

47. 5 feet sandstone.

48. (At this point I take the section from the southerly side of the creek, the northerly side being obscure.) Here 8 feet of shales and sandstones, alternating in beds of from 1 to 2 inches in thickness, were exposed. The topmost layer is a black soft seam, partaking of the character of slaty coal (4½ feet), but not clear. Dip of bed 28°.

49. 7 feet fine brown sandstone was apparent, but the bed was a very broken one, and not continued with any regularity.

50. Seam of slaty shale, 4 feet.

51. 7 feet hard black sandstone shales, with indistinct vegetable impressions.

52. 20 feet bed of shaly seams, alternating with thin layers of sandstone, in one instance reaching the thickness of 16 inches.

53. Fine (?) white sandstone, with (near the top) slight layer of black matter, looking like coal, and shaly matter, mixed as in bed 52; 6 feet.

54. 30 feet of irregular seams of brownish sandstone, slaty shales, and 1 inch of soft slaty coal. These layers are so irregular that I cannot properly tabulate them.

55. 6 feet brownish medium-grained sandstone, dip about 39°.

56. Shaly slates, &c., 35 feet.

57. White gritty sandstone, dip 37°.

Here another trap dyke ("B") cut across at an angle of 8°. At one time it must have extended in an unbroken wall right

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across the stream, but it is now as at "A" dyke, broken by the torrent which now tumbles over it in a pretty waterfall. General course of this dyke is S.W. and N.E.; average breadth 6 feet. The rock contiguous to it (on the further side) is the same as 57 bed (indeed only a division of that bed). This dyke also cut across 58, 59, and a portion of 60 beds.

58. Black shale, irregularly bedded with small irregular seams of sandstone which cannot be tabulated.

59. Six feet white medium grained sandstone. At 59 bed this is now again continued on the north side of the creek, where it is more distinct than on the south side.

60. 3 feet black splintery scaly shales.

61. White sandstone, 3 feet.

62. 10 feet irregularly bedded shales and sandstone mixed—very faint fucoid-like vegetable impressions.

63. 25 feet white sandstone, 31° dip.

64. An irregular series of thin beds or layers, which may be tabulated as follows :—

α. 4 feet splintery shale.
β. 4 feet white sandstone.
γ. 8 feet irregular shales and sandstone.
δ. 4 feet white sandstone.
Black shale.
θ. 4 feet white sandstone.
ζ. 6 feet irregular shales—topped by a small seam of softer splintery clay shale.

65. 25 feet (estimated) thickness of white sandstone.

66. 10 feet black splintery shale.

67. Bed 18 feet thick, commencing at the bottom with beds of shale, and ending superiorly in brownish sandstone with slight seams (1 inch thick) of shale.

68. 20 feet soft scaly layers of shales, the uppermost one a more perfect slaty seam.

69. 12 feet hard grey sandstone.

70. 5 feet laminated slaty shales.

71. 10 feet hard greyish sandstone.

72. α. 3 feet shales and sandstones.
β. 6 feet sandstone.

73. 8 feet laminated shales and sandstones.

74. 8 feet hard grey sandstone.

75. Bed 80 feet in thickness, composed of irregular shales,

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sandstones, &c., so high up as to be indistinct, and below I could not trace it, being covered by debris. I counted in the portions exposed three beds of sandstones and four of shale.

76. Coal, 1 foot.

77. White sandstone, 2 feet.

78. Splintery shales, 4 feet.

79. Hard greyish sandstone, 20 feet. A narrow spur of trap from "C" dyke runs perpendicularly through this.

80. Many irregular seams of sandstone, shale, &c., to the thickness of about 25 feet.

81. Hard grey sandstone, mostly washed by the torrent.

Between this and 82 a trap dyke "C" runs. Its course is N. Mag., rising in the direction of Atanakerdluk Basaltic Headland, intersecting the beds at an acute angle, and about at right angles to "A" and "B" dykes.

82. Irregular beds of sandstone, shales, to about 45 feet.

83. Grey sandstone, 8 feet.

84. Brownish, hard grey sandstone, 4 feet.

85. Black shaly coal (?), 6 feet.

86. White gritty sandstone, with perhaps a layer of shale intervening, but I could not trace it satisfactorily, 60 feet. Hitherto the valley of the creek (for the stream at this time was small), which was about 200 feet wide at the mouth, and had been gradually contracting, rendering progress more difficult, now again opened out, but I found myself unable to trace the beds farther in this branch. I now travelled about 200 yards north, and came on another branch of the creek, which unites with the first at dyke "C", where I could follow the section again, but the day getting late I was more hurried than I could have wished, and had therefore to be less minute in the enumeration of the beds than previously. They may be summed up as follows, taking the enumeration first where I left off:—

87. Here was exposed from the bed of the creek, to near the pinnacled summit of the hill, where I had made a minute section the day previously, about 80 feet of beds composed of brown sandstone, shales, clayey iron-stone, or siderite (in which the fossil impressions are chiefly found), coal, &c. In ascending order they were as near as need be as follows:—

a. Splintery shales 12 feet.

b. Bed of coal, 2 feet.

c. Laminated hard shales intermixed with splintery, brown (?)

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sandstone (gritty), but at this place there was much debris overlying the section, and the sequence could not be very clearly made out.

d. White gritty sandstone.

e. 2 feet of the clayey sideritic shale—the same as the fossil leaves are found in, but it could not be reached except by great and long labour.

f. Irregular shales, 10 feet.

g. About 20 feet of irregular shales with pieces of broken layers of coal scattered irregularly through it.

h. Shales, &c., with little pieces of very lignitic coal irregularly scattered throughout the mass. This bed was some 10 feet in thickness.

I now came to the place where I had made a very minute section the day previously, and for the purpose of shewing the minute bedding of the layers of stratified rocks (shales, sandstones), &c., here I may be allowed to give it in detail, classing all the beds under the general heading of—

88. Many thin beds of sandstones and shales.

(1.) A few inches of sandstone.

(2.) Thin layer of clayey shale.

(3.) Thin layer of sandstone, same as (1.)

(4.) 1 inch layer of sideritic clayey shale, same as the fossil impressions are in.

(5.) Sandstone, as before, 1 inch.

(6.) Shaly layer, 1 inch.

(7.) Sandstone, 2 inches.

(8.) Shaly layer with pieces of coal.

(9.) Sandstone.*

(10.) Thin layer of clayey ironstone, same as fossils are contained in.

(11.) Scaly layer of shale.

(12.) Sandstone.

(13.) Scaly layer of shale.

(14.) Thin seam of coal.

(15.) Sandstone, 1 foot thick.

(16.) Shales, 6 inches, with a broken

(17.) Thin layer of coal in the middle.

(18.) Layer of clayey siderite with fossils, 2 inches.

* When the thickness is not mentioned it is to be presumed that there was a mere trace.

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(19.) Sandstone, 1 foot.

(20.) Shaly layer mixed with fragments of coal, same as (6.)

(21.) Excessively splintery slaty layers with very faint fossil impressions. All these layers were much weakened.

(22.) Thin layers of sandstone with a small broken seam of coal. There are 4 inches of sandstone, but mere fragments of coal.

(23.) Splintery shaly layers with very faint fossil impressions. The shales crumble away in the hand—a few fragments of this sideritic shale are found on the top.

(24.) 1 foot coarse-grained white sandstone, as before.

(25.) Layer of splintery shales, as in (23.)

(26.) Coarse gritty sandstone, 14 inches.

(27.) Splintery shaly layers, 18 inches (as in 23), with faint vegetable impressions.

(28.) Coarse gritty sandstone, *with here and there little specks of coal in the sandstone.* Much of this sandstone contains iron, and the exterior is much stained by oxidation, but irregularly in patches.

(29.) 3 feet splintery shaly layer with imperfect vegetable impressions of same nature as before. Some portions of this bed are in bluish-black layers, others reddish, but the traces of vegetable impressions are equally distributed and equally imperfect.

(30.) A seam half coal, half shale, 1 inch in thickness, but very indistinct.

(31.) Coarse gritty sandstone much oxidised, 4 feet.

(32.) Splintery shales with faint impressions of leaves, &c., but so brittle that I found it impossible to get them, the shales crumbling into minute scale-like fragments when touched.

(33.) 4 feet of gritty sandstone mixed with thin layers (not exceeding 2 inches) of shale as before, but so irregular as scarcely to be classed as separate. I counted eight pretty distinguishable.

(34.) 2 feet splintery shale with faint vegetable impressions, but the stone (as before remarked) not of a nature to retain them.

(35.) White gritty sandstone, 8 inches. This layer is not oxidised or weakened.

(36.) 1 foot gritty sandstone without oxidisation.

(37.) Thin layer of shale.

(38.) 2 feet gritty sandstone.

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(39.) Shaly layers, about 3 inches.

89. The bed here shews sandstone on the top, but its inferior termination could not be traced very distinctly, it being covered with talus from the hill above, but to all appearance the section followed the same sequence as before, for 2 feet. On climbing up to a place where I could again get a section free from the debris of shaly splinters, I found that shale seemed to predominate, and the ground was, as below, scattered with fragments of the cherty iron-clay slate so frequently referred to as the matrix which has preserved the fossil impressions so well. Nowhere were the layers of this last named rock more than 1 or 2 inches thick, and on lifting it, it broke into squarely angular fragments, rendering it very difficult to get anything but fragments of the larger leaves. This bed might possibly be in perpendicular depth 100 feet, and when it was possible to get the dip their angle of inclination appeared to be about 30°, strike E. These beds were succeeded by

90. Miscellaneous irregular beds or schists of sandstone and shale again, consisting of—

(1.) Layer of fine sandstone, 10 inches.

(2.) Layer of same shaly substances as before, and of the same splintery nature, 5 feet.

(3.) A layer not very distinctly marked of shaly sandstone, 10 inches in thickness.

(4.) Shale beds, 6 feet.

(5.) Layer, as in (3.), of shaly sandstone, 8 inches.

(6.) Splintery shaly bed, 8 feet.

(7.) Shaly sandstone, as in (3.), 10 inches.

(8.) Splintery shaly beds, 12 feet.

(9.) Shaly sandstone, 8 feet; but between the last two I counted five seams of an average thickness each of 1 inch of sandstone, one or two of which are gritty. They were however indistinct, and sometimes attached to pieces of the cherty iron-clay slate, siderite ("Atanakerluk-stone" of the Greenland Danes), which is nearly of the same nature as the shales, and in some places occupies the same relation to the sandstone as does the latter.

(10.) Splintery shale, 8 feet.

(11.) Broken layer of fine sandstone shale, as in (3.)

I had now reached the summit of the hill, and beyond this my section does not extend into the Noursoak Peninsula. The talus of splintery shale and sandstone now rolled down on the

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opposite slope into a hollow from which another hill ascended, and as far as could be seen the same nature of country prevailed through the peninsula—bare hills jagged into fantastic shapes, or more often rounded bosses of the trap-eruption, which gives the character to this peninsula. This hollow was green with vegetation, and the melting of the snows ran coursing throughout it in icy-cold streams. On the contrary, the slope facing the sea, denuded every summer by currents which pour down its face (and which have broken up the soft shales and sandstones into the sand-clay out of which we dug the cherty iron-clay slate containing the fossil impressions, the nature of this rock enabling it to withstand the disintegrating influences which had reduced to their original elements the softer strata with which it had originally been co-embedded), was bare of plants, except a few stunted specimens of *Salix arctica* and such like hardy plants, which had managed to hold their footing in the soil. I now travelled some little distance inland, expecting to find the geology to be similar, but I could see nothing but the trap hills I have referred to, the slope and base strewed with a talus and blocks which had tumbled from above, rent by the frosts of winter. This trap where it bursts through the strata, often stands out in the bare weathered dykes which I have spoken of and noted in their proper place, surviving the wreck of the sedimentary strata which had once clung to them. These dykes run in regular lines intersecting the strata obliquely. One of these weather-beaten masses is quite picturesque, standing bare and solitary in an obelisk-like pinnacle, on the slope facing the amorphous basaltic headland of Atanakerdluk, which is only connected with the mainland by a sandy neck. As this peak forms a remarkable landmark from sea, I may be allowed to designate it as *Rink's Obelisk*, in memory of my friend Dr. Rink, the ablest geologist who ever visited Greenland, and the discoverer of the fossil beds, though he did not seem to be aware of the importance of this observation. The height of this obelisk is about 80 feet, and the side next the hill seems almost as if built, but the one facing the sea is more sloping and jagged. On various places on this declivity, I saw travelled blocks of grey syenite and one or two of greenstone (different from any of the trappean rocks of this vicinity), and as the rocks from which they have come cannot be found *in situ* in this vicinity, their presence here is possibly due to ice-action. I may note, however, that nowhere

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in the vicinity did I see any distinct marks of the country having been overlain with ice, and to this may be probably due the fact of the soft sedimentary beds alone remaining in this section of country, while in the rest of it, which everywhere bears marks of ice-action, nothing but the hard bare primitive rocks remain. From this point we had a fine view of the opposite shores of Disco and the top of that island, called "Kekertarssuak" by the Greenlanders.* From where I stood it seemed as if the cliffs terminated abruptly—though in reality there is a considerable slope between the foot of these cliffs and the sea—and that the surface of the island is flat and covered with a *mer de glace*, apparently only a miniature of that covering the mainland, with its overflow bursting over the cliffs in glaciers. The late Inspector Möller, when his boat was destroyed on the Disco shore south of this by the reflux of the sea caused by the capsizing of a berg, reached Godhavn by walking over this interior ice.

In Professor Heer's paper "On the Miocene Flora" in the *Journal of the Royal Dublin Society* (*l. c.*), a sketch is given by Commander Colomb, R.N., of certain fossil stems which he and Captain (Admiral) Inglefield, R.N., saw in this locality at the time of their visit. I searched very carefully for them, with their description in hand, but could nowhere see them. There had apparently been a landslip in the neighbourhood of the place where they describe them as standing, and they are doubtless buried under the debris. They are certainly not there now.† Capt. Colomb's sketch is in general intelligible enough, but if done on the spot I cannot understand some parts of it. There is no coal to the left. After collecting a large quantity of fossils here, and getting them laboriously carried down to a roofless house used at one time to contain the coal, which it was proposed to mine in the vicinity for the use of the settlements in Disco Bay, I walked southerly along the coast in the direction of Tartarak, the southern headland, to examine certain sections in that vicinity. An old Eskimo woman accompanied me as bag-bearer and general hench-*woman*.

* On the authority of Hr. S. Kleinschmidt's Eskimo map of Greenland (*Sinerissap Kavdlunâkarfilgta*). Th. Bergh, Kjobenhavn, 1870.

† Nordenskjöld describes bituminised stems found in this locality by him with the roots so permeating the soil as to leave no doubt but that they grew *in situ*.

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In sight of the camp she was exceedingly demure, but no sooner did a projecting cliff put us beyond the reach of any scandal than my venerable "gilly" commenced a most voluble talk in Eskimo and very dubious Danish, with a few English words which she had picked up somehow or other, and very proudly dragged in on every conceivable occasion. As might be expected, my linguistic accomplishments not being so extensive as hers, I failed to benefit by the whole of the never-ending discourse with which the good lady favoured me as we jogged along in the most friendly manner. I learned, however, that she was rather astonished at my pursuits—though she understood that their general intention was reputable, for did not the Royal Inspector, Mr. Olrik, and Mr. Andersen of Ritenbenk, the two greatest men she had any personal knowledge of, not even excepting the *nalagak-soak*, with whom she had the honour of conversing —occasionally amuse their lighter hours with similar recreations? On the whole, however, *she* held rather a poor opinion of geologists *in general*, and couldn't really understand why they left good coal (aumarssuit) alone, and took those stones—most of all why we should take the trouble to put them in paper, which doubtless cost some money in Kjöbenhavn! Still there was no accounting for the foibles of white men, for did not they erect a house with a roof on it to keep the coal from the weather, after it had lain there exposed to the weather for innumerable years? And then, as this piece of cheap learning did not seem sufficiently to impress me, she informed me that I need not doubt it, for she heard Pastor Balle say so. Sketching the strata, using the compass and clinometer equally astonished and disgusted her, and volubly did she express her opinion on men and things geological, until the camp came again in view, when suddenly she was as demure as possible. However, all night long I heard her describing the wonders of that day's journey—what *she said* and what *I did*—and all the particulars anent and touching said acts and words: I expect she is talking yet. The result of *our* conjoint labours were the following sections:—

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(β.) *Section about* 1007 *yards S.E. by S.* (*Mag.*), *from House at Atanakerdluk in cliff facing the sea.**

1. Brown sandstone, 2 feet, dip 33° (on the top).

2. Seam of clay slate and shaly coal, irregular thickness, average 8 inches.

3. Seam of coal, 2 inches.

4. Scaly shales, 6 inches.

5. Whitish sandstone, stained with brown, 2 feet exposed. In the clay slate faint impressions of plants appeared, and in the sandstone where it joined the slate, but so imperfect as not to be distinguishable except as charred spots (I use the term shale and clay slate here synonymously—the latter is however used when the rock to which it is applied is rather firm). Most likely bed No. 5 is No. 1 of the section (α), but this bed (No. 5) becomes obscured by debris and pieces of trap fallen from the dyke "A", which extends here right across the strata. Farther along No. 1 is again exposed along with shale, and can be traced for some little distance, but it soon drops out off sight. The sandstone No. 5 here becomes fully exposed to a thickness of 6 feet, interstratified with what I call sandstone and shale, succeeded by 16 inches slaty lignitic coal with faint impressions. This is again topped by 8 inches of white sandstone, succeeded by 3½ feet of slaty shales, pale grey and black; again 4 feet white soft sandstone, interstratified at the top of the seam by a thin seam (2 inches) of sandstone and shale mixed. This is topped by black shales, here dwindling away to 6 feet, though doubtless from their position and dip it is one of the thick beds exposed up the creek. The bottom of this bed of shale is a slaty description of coal, separated from the sandstone beneath by 2 inches of shale, but the beds cannot be separated. After proceeding along the beach for 1½ mile (English) the trap dyke appears coming down perpendicularly through the strata, and sending a transverse vein to interstratify between sandstone and the sandstone and shale. Previous to this—*i.e.*, more northerly, another perpendicular vein comes down from dyke "A" in the same direction (S.E.), but not so well marked. The angle at which the spur of trap interstratifies

* This I consider the same as the series up the creek previously described (α), the lower beds however, owing to the dip being exposed here, farther down that at the mouth of the creek.

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is 61°, but it keeps the same angle throughout until it ends in a protruding knob. The strata are slightly tilted at the line where the dyke spur cuts through them; on the northern side the dip of this white sandstone being 47° S., while that of the strata on the other side was 61° (or the same as the trap spur) and dipping slightly northward. The strike of all the strata is however the same (N.E. Mag.). The white sandstone mentioned resumes its former dip on the other side, and there does not seem to be deflected by the dyke. The sandstone referred to is a coarse gritty rock, and, as formerly remarked, when in contact with the trap rock, does not seem to have been much metamorphosed, though doubly in contact *; indeed only to such a small extent as to render the traces of this a matter of much nicety. In some places on the line of contact between the two kinds of rock, the trap seems, if the phrase may be used, to take the character of the sandstone, being soft, crystalline, and easily broken with the hand. On the other hand, the grit in contact with the trap does not seem to differ from that in the normal state, but in most cases to have been melted by the heat, a thin glaze being formed on the surface. The height where my whole section extends, is about 1,180 feet (by aneroid),† and the section is continued pretty uniformly, as I have given it, N. and S.; though, of course, on the surface facing the sea the strata were denuded in many places. In some places from the height, I suppose that a similar section, following a similar uniformity and alternation, could be traced farther than even this, (say) 1,200 feet, for we could see the strata northwards in the cliffs at a much higher elevation than this. Time, however, would not admit of my making the necessary explorations, though months could be most profitably spent surveying the Noursoak Peninsula and Disco Island. I do not suppose, however, that even had we been able to follow up this section, that the observations made at a greater height would have materially altered the conclusions regarding the alternations of coal, sandstone, and sideritic shales, made on the section already observed and here described. However, these lines of the white stratified rocks running in relief against the black basalt cliff bursting through them, are very plain, and a curious feature of this coast. There appear to be

* Nordenskjöld subsequently noticed the same fact.
† As noted by Mr. Whymper (*vide* note on p. 71).

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occasional faults in the strata, but the distortions by trap eruptions are little.*

2. *Ouiarasuksumitok.* Lat. 69° 51′ 2″ N., Long. 52° 19′ 6″ W. (Nordenskjöld).—We leave Atanakerdluk on the 24th of August and cross to the Disco shore, where at a newly established outport of Ritenbenk we are hospitably received, in the absence of the trader in charge†, by Paulus a native catechist. Paulus is a hospitable man, and grins from ear to ear as he conducts us through the gaping crowd of natives who assemble to look on what were no doubt to many of them the first Englishmen they ever saw. We sleep that evening on the floor of Paulus' hut, and without wishing in the smallest degree to disparage the kindness of that worthy man, his buxom wife, fair sister, five children, brother-in-law, and numerous other kinsfolk, who all shared with us the floor of the mansion in question, we consider it a duty to all who may succeed us, to record in this place, that before morning we appreciated the inestimable blessings which ozone confers on asphyxiated mortals. I have certainly slept in many strange places in many parts of the world; but the amenities of the hut of Paulus, the Eskimo catechist of Ouiarasuksumitok, were such that until the end of time I am not likely to forget my experiences of it. Ouiarasuksumitok is a pleasant sunny place, built on a flat, backed by great fells of trap (greenstone), and rocks of the same primitive formation lie in the sea a little way off the shore. A little way north of the settlement, I saw "pig rootings" (as Giesecke forcibly, though perhaps not very elegantly, styles the Greenland coal mines in his day) in the cliff at the water edge. The section exhibited sandstone, a small seam of shale, 2 feet of lignitic coal of a poor description, though the natives burnt it in their stoves; the whole resting on trap. Ouiarasuksumitok means the place where the coal is mined out, and was chiefly built for the convenience of the coal mines at Ounartok. It is also called Ujararsusuk.‡ It was in a boulder

* From the examination of some fossils from the lower strata at Atanakerdluk, Dr. Heer is of opinion that possibly these lower beds may belong to the Upper Cretaceous. The fossils on which he founds this opinion are *Cycadites Dicksoni*, the frequent occurrence of ferns, a *Sequoia* allied to *S. Reichenbachii*, and a *Credneria*. They have not yet been described.

† This official, generally a cooper or carpenter, is a sub-trader under the nearest "Colonibestyrer" (best man of the colony, or district governor), and is styled by the Danes an "Udligger," "out-liver," literally, though most amusingly translated in the *Geol. Mag.* (*l.c.*) as "emissary").

‡ Some confusion seems to have arisen in regard to these names. In Pro-

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in this locality that Dr. Pfaff found a *Sigillaria* and *Pecopteris* (?) probably of carboniferous age.

3. *Ounartok* (*Ritenbenk Coal Mine*).—Three hours pull north of Ouiarasuksumitok is a creek of this name, where we next proceeded by the direction of Paulus. This part of the coast is called on Rink's map "Ritenbenk's Kolbrund" or Ritenbenk Coal Mine, as I have given it on the map attached to this paper. Here we halted, as Paulus told us there were fossils and amber here; but on further inquiry it turned out, as Eskimo evidence, even of more than ordinary trustworthy sort, almost invariably does, not altogether to the point, for he knew of no fossils, and had only *seen* one or two small bits of amber (retinite) in the coal. A few days before our arrival some coal had been taken from this place for the Disco Bay settlement, and I examined the place where it had been mined. It exhibited shales resting (?) on trap, topped again by medium grained white sandstone, this apparently covered by coal (for along the beach there was a face of 3 feet of lignitic coal exposed, though the floor was of coal, and therefore the seam appeared to extend to a still greater thickness), covered again by 1½ foot of shale, this by 10 feet of coarse brownish grit, then 2 feet of hard brownish sandstone, finally 4 feet hard grey sandstone discoloured in some places by iron. On this alluvial soil rested some stratum or strata, having however to all appearance been denuded. The dip of these strata was about 33°, the strike easterly (across the Waigat). Both the shaly sandstone and grit contained innumerable impressions of stems, interlaced in every direction, more particularly in the shales; but as at Atanakerdluk (nearly opposite) there were no *leaves*, and most of the stems in the shales appeared only like lines of charred wood. What is called Ounartok is probably what was once a native "house-place," and it is yet a favourite camping place for wayfaring men who, like us, now and then (rarely indeed) visit this solitary coast. Here a gurgling creek falls into the sea. Much debris has been brought down by this creek as it dashes from the mountains and the interior ice through the sedimentary

fessor Heer's paper in the *Phil. Trans.*, *l.c.*, Ounartok is repeatedly called by the two names of Ujararsuk and Ouiarasuksumitok, while that of Ounartok applied to the locality where the coal is *at present* mined is never mentioned. The two localities are totally different, and are named as I have given them, my authority being the very sufficient one of mine host, the intelligent native catechist who resides there, and who wrote them down in my note-book as above.

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strata which lie in its way. In pieces of brown sandstone, &c., in this debris, Gudeman and Pavia, two of our native boatmen, found fair impressions of leaves, though these had not been hitherto found in this stratum. It was this Gudeman, a remarkably intelligent and remarkably dirty native, generally styled Diogenes in our party, from the fact that his house, if not a cask, had at least one for a chimney, and that in Cynical philosophy, as well as in dirt, he somewhat resembled the ancient of that name, who discovered the fruit of the *magnolia* (*M. Inglefieldi*, Hr.), which was not the least important item of our collection.* M. Olrik however, according to a note in my possession, written by himself in my note-book (April 25, 1867), found leaves in the sandstone at Ouiarasuksumitok. I followed up these impressions found in the brown sandstone by the two natives, and discovered the rock to have broken out from the little stratum of hard brown sandstone in which, as well as in the sandstone and shales already noted, we discovered fossil impressions, but hitherto very imperfect. These comprehended dicotyledonous leaves (*Populus*, probably *P. Richardsoni*, Hr.) and fronds of *Aspidium Meyeri*, Hr. and *A. Heerii*, Ett.; but it was very difficult to obtain pieces of the rock on account of the superincumbent mass of strata, which it would scarcely have been in our power to blast out. Finding that very little more could be done at Ounartok, we left that same evening. All the way north to Kudlisaet, the sedimentary rocks, backed by basalt in terraced cliffs, appear on both sides of the Waigat, until about one mile south of Kudlisaet they are obscured by an immense talus (?) of trap fallen from the hills, looking like the refuse of some gigantic quarrying operations. We arrived at Kudlisaet after dark, very cold, and camped on a flat place just above high-water mark. On the cliff above, on a great trap block, were erected some stones, the work we were informed of some English ship's crew (perhaps M'Clintock's).

4. *Kudlisaet.* Lat. 70° 5′ 35″ N.†—This was our most northern

* Both he and Pavia (natives of Sakkak) were capital assistants, and I can safely recommend them to any other travellers who may require native assistance. Both are rather lazy, but that is a national, not an individual weakness, and in this they are not worse than their fellows who are not as intelligent.

† In the map attached to Professor Nordenskjöld's memoir, already quoted, Kudlisaet (Kudliset) is apparently applied to a locality in lat. 70°, while the locality of Kudlisaet is marked as Ritenbenk Coal Mine ("Ritenbenk's Kolbroff"). A locality still farther to the south, on a stream, is marked on

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locality. Here are green mossy slopes, but the vegetation on the whole was on this side much more backward than on the Noursoak shore. An *Arabis* and *Stellaria Edwardsii*, R. Br., were frequent on the dry places, but I saw little of *Hierochloe borealis*, so abundant elsewhere. The glaucous willow (*Salix glauca*) was common, and *Elymus arenarius* gave a link-like character to the sandy shore, while a little marsh at the mouth of a little creek, to be presently referred to, was thick with *Equisetum arvense* and *E. variegatum*.

Opposite Kudlisaet is about the highest point of the Noursoak shore, and was capped with snow like the land on the Disco side, where the snow lay on all the elevated places, and even in the hollows close to the sea, wherever the sun did not reach it. Opposite Kudlisaet is also a valley in the Noursoak Peninsula, which is called "Akudliorosorosoak," and is a good landmark for reaching this portion of Disco Island. Behind, on the Disco shore, are three or four great trap cliffs, which are prominent landmarks. They are called by the natives "Kudleikseit" (the lamps; kudleik, a lamp). Hence, probably, the name of the locality.

(*a.*) *Section along the Shore at Kudlisaet.* In the morning I walked southward along the beach, and found the following section exposed:—

1. Alluvium of earth, debris of rock, &c., from cliffs behind; 20 feet.

2. 5 feet coarse gritty brown sandstone. On the outside it is so very soft by disintegration that it is difficult to say whether it is sand or sandstone.

3. 14 inches hard grey sandstone.

4. 1 foot hard sandy shale, with vegetable impressions, &c.

5. 14 inches of coal, exposed by men attempting to work it at a place where a little stream breaks through the strata. The coal is of the same nature as the rest.

6. Shales, 2 to 3 feet.

7. Hard sandstone, 3 feet.

Nordenskjöld's map as "Igdlokungoak." It is in about the latitude of Ounartok; but as I had no opportunity of taking observations to determine the latitude (as apparently Professor Nordenskjöld had not either), I cannot be certain. As we were very careful in getting the exact names from our native boatmen, all inhabitants of the immediate vicinity, I cannot but consider that they are correctly given by us.

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8. Shales, standstones, &c., irregular seam; 2 feet.

9. Hard sandstone, 1 foot.

10. Shales, 2 feet.

11. Hard grey sandstone, *with pieces of coal contained in it.* About 14 feet of this is exposed at the head of the beach, where it was impossible to follow the section deeper in this place.

The dip of the strata is here N., strike E. across the Waigat. The section is exposed along the beach until close to the place where are the "stones erected by the Englishmen," where it is totally obscured by debris, and instead of cliffs there are smooth, rolling, turfy slopes. This section, where it disappears, has a dip of 45°. Scattered along the beach and on the slopes are great blocks of breccia-like material,* apparently the peculiar basalt referred to already (see p. 63), which have rolled from the mountains, but I was not able to find any of it *in situ.* These mountains are great protuberances of basalt (Kane calls this "a greenstone dyke stretching across Disco Island," but he is, I think, *mineralogically* wrong), giving the place its character as noted.

(β.) *Geology of Heer's Creek.*—A little to the north of where we were encamped, a considerable creek flows into the sea, in a general course easterly from the interior of the island. To the section exposed by this creek we next devoted ourselves. This stream is not marked on the otherwise excellent map of this coast, and though I have not the presumption, on one hurried run along it, to attempt to correct the work of such experienced chartographers as Graah and Rink, yet as this stream must be frequently referred to, for convenience sake I may be allowed to apply to it the name of the distinguished botanist whose labours have made these beds famous in the scientific world, and to whom science is in reality indebted for all that it knows of the miocene flora of the Arctic regions.† In this creek we had been previously informed by Mr. Andersen, of Ritenbenk, that he had found fossil stems. Gudeman, who had accompanied him, soon pointed them out to us. They were lying in fragments in the stream, mixed up with pieces of sandstone containing impressions of leaves. The stems were much broken, but the dicotyledonous character of them was quite apparent—the annual

* In a note on this in the *Phil. Trans.*, *l.c.*, inadvertently I have called this a *conglomerate.*

† Mount Heer, in Spitzbergen, and Cape Oswald Heer, in east Greenland, are also named in his honour.

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rings, knots, and bark being yet visible. One we saw lying beside where Mr. Andersen had got his, but this he could not get into his boat. It was whitened outside, but internally the vegetable matter had been replaced by a dark cherty substance. These stems might, however, be passed over by those not acquainted with the nature of fossil stems as mere blocks of stone.

I may here mention that at Ounartok I picked up a piece of material which, at first sight, I took to be some cellular form of fossil wood (lying on the beach), but on closer examination it appeared to be part of the spongy skull of a *Balæna* or *Balænoptera*. It was quite fossil, and those acquainted with the close resemblance at first sight of some kinds of fossil bone and wood will understand the difficulty of at once distinguishing them. A perpendicular section facing the creek at the place where these stems had rolled down (as it afterwards appeared) out of the coal, shewed, from the level of the creek upward, the following beds :—

1. (Bottom) 4 feet splintery shales.*
2. 1 foot hard gritty sandstone.
3. 4 feet mixed shales and sandstone.
4. 1 foot coal.
5. 1½ foot shale, with faint impressions of leaves, stems, &c.
6. 2½ feet coal.

In this last coal (No. 6) are the stems previously referred to. They lie apparently horizontally E. and W. and N. and S. (Mag.), and a transverse section of this is exhibited in the face of the coal. The direction of all of them is not constant, and is more difficult to satisfy oneself of than might be supposed. They are only in fragments, brownish outside. In most of them the bark is off, and the inside is of the hard black cherty substance just mentioned as composing those lying in the bed of the stream. Coal is, according to my observation, invariably all around the stems, the shales not coming in contact with them.†

* I would remark here the absence of the "dirt bed," the significance of which all geologists will understand.

† In reference to an idea which I mentioned to him that the leaves were never water-floated, and that the stems grew not *in situ*, but were probably water-floated then in much the same way as the drift-wood which now accumulates in great masses in certain places about Disco Bay and other portions of the Arctic regions, Professor Heer (*Phil. Trans.*, *l.c.*, p. 456), replies :—"It may be so; but as no marine miocene animals and plants

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7. Shales, 18 inches.
8. Sandstone, with leaves, &c., 3 feet.
9. Small seam of soft shale.
10. 1 foot coal.
11. 4 feet shale, soft and splintery.
12. 1 foot coal.
13. 3 feet soft, splintery, brownish shales.
14. Whitish gritty sandstone (?).
15. Soil.

I climbed up to where the stems lay, and disinterred several isolated fragments. They were assuredly not erect, and seemed, as I have said, to be horizontally E. and W., others N. and S., but more the former direction. Only fragments now remain, for the strata in which they are contained must have once extended right across where the creek now runs, and the rest of them must have been long ago swept away by the torrent. The fragments now lying in the bed of the stream seem to have been thus washed out. On the opposite side of the creek (N. bank) there were green sloping banks, with fragments of trap, half covered with moss. From this bank I followed the shore northward for some little distance across the slope, where the strata had been denuded by torrents, but could be traced, as in the same series, in sections exposed on the banks of numerous creeks tearing down from the mountains. One of these torrents had brought down an immense mass of trap debris, forming a long "gravelly" beach of the fragments, over which it now runs for a considerable distance parallel to the sea, before emptying into it. Close to this place was the bare face of a slope, scattered over with fragments of silicified fossil wood and portions of stems out of strata similar to those already described.

5. *From Kudlisaet to Ritenbenk and Godhavn.*—By this date (August 27), we had collected more fossils than our boats could with safety convey to Ritenbenk, and as the season was getting late we prepared to return. Selecting as many fossils as we could carry, and some of the best pieces of the stems, such as could be conveniently handled, I left for Ritenbenk with my Eskimo crew of men and women, my other companions

were found either at Disco or Atanakerdluk, it is more probable that the fossil stems were drifted by a river, and that the lignites of the brown coal issued from trees of the moors in which they sank. At present this occurs frequently on the moors. The fact that they are lying in every direction, and enveloped by coal, accounts for it."

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remaining behind to assort the rest of the fossils, &c. I kept down the Disco shore for some little distance, but finding nothing more than I had already observed, we took advantage of a strong northerly breeze, which cut us to the bones, and ran south to Atanakerdluk, arriving there in five hours. I noticed that on the basaltic headland of Atanakerdluk part of the sandstone strata still remained to a small extent in contact with the basalt, but mostly washed away by the sea. Faint streaks of white in the cliffs, shewing that the miocene beds still continue, can be observed in the face of the trap or basalt cliffs as far south as the headland of Tartarak, but grow smaller and smaller, and less distinct and still less distinct, until by the time we arrive at Sakkak they have, with the exception of a small patch behind that settlement, altogether disappeared. Here again the old granitic and gneissose rocks appear to be continued in an almost unbroken uniformity down the coast. A cold icy wind soon took us to Sakkak, which, after our northern run and steady commons of seal soup, appeared quite a luxurious place rejoicing in all the good things of the season. Here again the solitary lord of the land entertained me like a gentleman (as he was) on reindeer and seal and narwhal skin, with the choice of a puppy which had just departed this life; but as I had already eaten what I considered my fair share of *that* luxury during my revels in beleagured fur posts in the wilds of America, I respectfully declined it, and slept the sleep of the just geologist on the family *brix*. A *little* of a bed in which you have five bed-fellows, in an unventilated room, eight by eight, is, even in an autumn night in Greenland, better than a *great deal*, so that on the particular morning styled the 28th of August, I ran no chance of missing my 8 o'clock observation for longitude. Thereafter I ran south, and in great state pulled by evening into Ritenbenk harbour, only to get a repetition of those kindly attentions from my friends Herr and Fru Colonibestyrer and Colonibestyrinde, which have made the name of Andersen a pleasant name to all weary Arctic voyagers, and in an especial manner most gratefully to be remembered by the writer of these words. At Ritenbenk, where I was followed next day by the rest of our party, we remained to the 31st of August, until the governor had completed his final despatches for the year. These once on board the "blubber-boat" for Godhavn he bids good-bye to the outer world until another year has come round. At

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the same time we bade good-bye to him, and set off to join the ship at Godhavn in which we proposed taking a passage to England. After a most miserable time of it we arrived at Godhavn (Lat. 69° 14′ 58″ N.; Long. 53° 24′ 40″ W.) on the 4th September. Though we lay for three wretched days storm-stayed in a little cove called "Akajaroa," yet, owing to the want of a small boat, we were unable to land. The miocene strata seem to continue down the coast to very near Godhavn, and coal appears at various places which I shall presently mention. At one place, called Skandsen (The Battery) by the Danes, appear regular basaltic columns. The north-east of Godhavn is built on a low syenitic island. Syenite also appears on the opposite side on the main island, backed by great fells of trap rising to the height of between two and three thousand feet. As this part of the coast has been so fully described both by Giesecke* and Rink,† it would be nearly a work of supererogation to re-describe it from my much more imperfect notes. I have only to add that the season being now far advanced, we took passage in the last of the royal ships leaving for Copenhagen, where after a long and tedious passage of six weeks we arrived in safety.

IV.—Greenland Coal.

(*a.*) The existence of coal in connection with the sedimentary strata of Noursoak and Disco Island has been long known, and of late years has come more particularly under the notice of the people of this country, from the fact that some of the English Arctic expeditions (Inglefield and M'Clintock's ‡) supplied their vessels with it from the seams at Kudlisaet and Atanakerdluk. Many years ago, owing to the attention of the Government being drawn to these home deposits by Mr. Candid. Pharm. Schythe, it was commenced to be mined for use in the Disco Bay settlements. It was, however, soon found that it was more profitable to employ the natives in ordinary fishery operations, and to import coal from Europe. Accordingly, for thirty years the use of it was discontinued. But since Mr. Andersen has had charge of Ritenbenk, the workings have been resumed for a few days every summer, and he takes out yearly about 300

* *Transactions of Royal Society, Edinburgh*, vol. ix., p. 261. (Read in 181

† *Loci cit.*

‡ *Voyage of the "Fox,"* p. 28.

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Danish töndes (barrels about the size of a sugar hogshead), which costs at the rate of 48 skillings, or about 1s. 1½d. per tönde. The coal is like all tertiary coal—rather poor, little coherent, and breaking with a cubical fracture, though bright and glistening in colour. It abounds in a small species of retinite, varying from a mere speck to pieces the size of a marble. I saw it burning in Mr Andersen's house at Ritenbenk. It gives off less smoke than English coal, the proof of which is that the pipe of his sitting-room stove never requires to be swept out all winter, though a fire is lit constantly. It gives as little ash as wood, and the heat-giving power he estimates as being only one-half of English coal. He generally mixes it with English coal, and finds the arrangement work well in every respect; for in the "General Taxt List" for Greenland in 1867 English coal is charged at the rate of 3 rd. 48 sk. (or 7s. 10½d.) per cask.

(δ.) Two analyses have been made of this coal. One is by Professor Fyfe, of Aberdeen, in the Appendix to *Inglefield's Summer Search after Sir John Franklin* (p. 151), and another by Mr. T. W. Keates, of London, in the *Philosophical Transactions* for 1869, p. 449. We place them side by side for comparison:—

	Keates.			Fyfe.
Specific gravity, . . .	1·369	...	...	1·3848
Gaseous and vol. matter,	...	45·45	...	50·60
Moisture, ...	...	·75	46·20	...
Sulphur, ...	...	...	·55	...
Coke, Fixed carbon, .	...	47·75	...	39·86
Coke, Ash, ...	...	5·50	53·25	9·54
			100·00	100·00
	The lignite contains a trace of bitumen; the coke is non-caking, and of little use.			

(γ.) In addition to the localities mentioned, coal has been found or dug out by the natives at various places on the coast. For instance, Dr Rink* mentions the following places, and Giesecke

* *Grönland*, vol. i., pp. 172—178.

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several others, where coal could be conveniently dug:—1. Atanakerdluk; 2. Patoot; 3. Atane; 4. Kordlutok; 5. Nulluk Cape; 6. Ekkorgvœt; 7. Mibersteen Fjeld; 8. Patsorfik; 9. Sarfarfik; 10. Kone; 11. Upernavik Cape; 12. Innerit Fjord; 13. Hare Island; 14. Ritenbenk Coal Mine (various places on Disco shore of the Waigat); 15. Skandsen; 16. Makkak; 17. Igligtsiak.

The first five localities named are on the Noursoak shore of the Waigat; the next five are on the Noursoak shore of Omenak Fjord, and most likely belong to the cretaceous formation, and not altogether to the miocene; the twelfth locality is on Svarte Huk Peninsula, in Upernavik district; while the three last-named places are on the southern shore of Disco Island—Igligtsiak being only 16 English miles from the settlement of Godhavn, to which the natives sometimes bring the coal on their sledges in winter.

Graphite in considerable quantities is found at Karsok and Niakornak, on the Noursoak Peninsula, and belongs most probably to the cretaceous or late miocene period. It is found in considerable abundance on various islands of Baffin's Bay and Davis' Strait, but has never yet been found profitable to import.

V.—General Conclusion regarding the Miocene Flora of Greenland.

I have now concluded my personal notes on the miocene beds of Greenland, and it may be expected of me that I should summarise the general conclusions which I consider the facts already gathered entitle us to draw. Though I scarcely consider that the observations and material are yet extensive enough to enable us to do so with the confidence with which it has been done by the eloquent and illustrious describer of our collection, yet it is undeniably right that the views of one who has devoted more attention to this subject than any other man should be carefully weighed. In a paper,* admirable in many respects, though not altogether free from errors regarding our expedition—his information has apparently been derived from some very imper-

* "Les Dernières Découvertes dans l'extrême Nord:" *Bibliotheque Universelle et Revue Suisse*, t. xxxix, April, 1869, pp. 512-543, translated by Mr. W. S. Dallas in *Annals of Nat. Hist.*, 1869. It has been published separately both in French and German. For a further description of Atanakerdluk, see also Heer's "Les Régiones polaries du Nord" (*Bibl. Univ.*, Jan., 1867, p. 51), and his great work already mentioned.

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fect or garbled notes—he has summarised these in a masterly manner. He remarks that, "At the period when the sandstones which compose the smiling hills of Zurich were deposited, a considerable extent of *terra firma* must have existed in the extreme north. To this period the name of miocene has been given, or more generally that of the tertiary period. Our countries had then almost a tropical character. Among the forests of laurels and the tufts of palm trees lived numerous animals belonging to types which now-a-days occur only in the warm and even torrid zones. Towards the north, indeed, the ground was clothed in a different vesture. Nevertheless Greenland, even at 70° N. lat., presents a flora which, by its climatic characters, may be compared with that of Northern Italy. This flora teaches us that in the neighbourhood of the islands of Disco and Atanakerdluk there was once a lake of fresh water, upon the marshy edges of which great beds of peat were formed. These subsequently gave origin to the deposits of coal which appear along the coast. In our marshes it is not rare to see ferruginous water, which covers the soil with a reddish-brown crust. The same took place in the ancient marshes of Greenland: the iron deposited itself upon the plants which fell into the water, and these in their turn contributed to the precipitation and fixation of the iron. By this means has been gradually formed that ferruginous rock in the bosom of which numerous plants are imprisoned. These fossils shew that the marshes were covered with sedges and reeds; but the marsh cypress, the water pines, the birch, the alder, and the poplar flourished there: for numerous fragments of these plants are covered by a ferruginous deposit. The water trefoil (*Menyanthes arctica*, Hr.) no doubt grew in the marshes in the same way that the existing species (*M. trifoliata*) adorns our moist meadows with its charming flowers; and the burr reed (*Sparganum Stygium*, Hr.), the fruit of which has been obtained from the rocks, also formerly raised its bristling head above the waves. The rivulets also brought in leaves from other localities; they conveyed them from the primitive forests; and it is thus that we find their traces in the ferruginous rocks. If we enter into these forests, we shall see a marvellous profusion of trees and shrubs, among which we can distinguish forty-five different species. A tree with acicular leaves (*Sequoia Langsdorfii*, Brogn.) strikes us at once by its enormous proportions. It has left leafy branches in such numbers that there is scarcely a

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fragment of stone which does not contain its remains; and the remains which the hammer has extracted from the rock enable us to reconstruct the entire tree. It is accompanied by two allied species (*S. Couttsiæ*, Hr., and *S. longifolia*, Hr.), one of which (*S. Couttsiæ*) by the configuration of its branches and leaves vividly reminds us of the *Sequoia gigantea* of California. A *Thuja* had a different aspect, as also the gingko (*Salisburea adiantoides*, Ung.), of which the leaves resemble the fronds of ferns, and differ so widely from those of other Coniferæ. The leafy trees are especially well represented; while our existing forests only present two species of oak, North Greenland possessed nine, four of which have been evergreen, like the Italian oak. Two beeches (*Fagus Deucalionis*, Ung., and F. sp. ——), a chestnut (*Castanea Ungeri*, Hr.), two planes (*Platanus aceroides*, Gœpp., and *P. Guillelmæ*, Gœpp.), and a walnut (*Juglans acuminata*), from this forest, resemble the types of the same name known to everybody. Besides these, American species, such as the magnolias, sassafrasses, and liquidambars, were represented there; and the characters of the ebony tree (*Diospyros*) are to be distinguished in two of the species. The hazel, the sumach (*Rhus*), the buckthorn and the holly, the guelder rose and the white (*Cratægus*), probably formed the thickets at the borders of the woods; while the vine, the ivy, and the sarsaparilla climbed over the trees of the virgin forest, and adorned them with garlands. In the shadow of the wood grew a profusion of ferns, which covered the soil with their elegant fronds. The insects which gave animation to these solitudes are not all lost. The impressions of these which have reached us shew that little *Chrysomelas* and *Cistilidæ* enjoyed themselves in the sun, and large *Trogsitæ* pierced the bark of the trees, while charming *Cicadellæ* leaped about among the herbage. This picture is not a dream of the imagination. Plants and animals have all passed under my eyes." In all about one hundred and sixty-seven species of miocene plants have been discovered in Greenland, and of these thirty-two were discovered by us.*

This is a pretty picture that the famous Swiss palæontologist draws, nor am I prepared to say that it is erroneous in any of its details. Still, however—it may be Scotch caution—I would

* "Om de miocena växter, som den Svenska expeditionen, 1870, hemfört fran Grönland, af Oswald Heer." (Ofversigt af Kongl. Vet.—Akad. Förhand, 1873, No. 10.)

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have you to think twice before jumping to the conclusion that no detail of its general character is beyond criticism. In the first place, 167 species of plants—most of them got from a locality in area not much larger than the room we meet in—is a large number, and betokens a flora more tropical than temperate, for I am not aware that any similar area in Italy (with the temperature of which Dr. Heer compares the miocene climate of Greenland) produces a similar number of species. Only the tropics, and there very favoured spots, could produce such a vegetation. Yet the plants found are not those of the tropics, but of temperate regions. Let us then examine the data on which the determination of these species have been made. In the first place, with every respect for Professor Heer, I must give expression to my opinion that many species are separated from closely allied ones by characters which he would be a rash botanist who would venture to separate recent species by. Then I hardly think there are sufficient grounds for separating many of those fossil species from recent ones, even when we have better characters than the mere leaf to go by. Many species are distinguished solely by the leaf—often a solitary specimen. Now, no botanist need be told that the form of the leaf on different individuals of the same species of plant varies much, and that in very many cases the leaves of the female plant differ from that of the male, while in almost every instance the stipular leaves are so entirely different from the radical ones, that if found fossil they would be pronounced those of different species or genera. It would be a mere waste of space to enumerate instances of this. Again, so imperfect are the remains of many species that the families to which *Daphnogene Kanii*, the *M'Clintockias*, and *Pterospermites* belong are, in Professor Heer's own words, "not satisfactorily determined, while the remains of the plants described by me as *Dryandra*, *Ficus*, *Ilex*, *Aralia*, *Rhus*, and *Nyssa* are questionable." This difficulty is perfectly acknowledged by Dr. Heer, but is one inseparable from all palæontological studies, and the skill he has displayed in identifying the often very fragmentary remains put before him, merits the lasting gratitude and admiration of all geologists. Even where it may be doubtful whether the specific determination is sound, he has supplied the data to judge for ourselves, and either to reduce or confirm his identification, as we may think fit. I only wish to guard against an idea that all is yet settled, or that future dis-

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coveries may not materially modify the conclusions so eloquently enunciated in the passages quoted from Professor Heer's memoir.*

VI.—List of Plants and Animals Found in the Miocene Beds of Greenland.

The following list, which I have drawn up from the various works of Professor Heer, will be found almost complete. It may not, however, embrace some recent discoveries which have reached Europe, such as some of the as yet unpublished collections of the Swedish expedition. But, nevertheless, it serves fairly well the purpose I have intended by printing it here—viz., to present at a glance a *resumé* of the nature of the Greenland miocene flora. What few animal remains were obtained by us at Atanakerdluk I have recorded; but it is not in my power to present a complete list of either the miocene or cretaceous fauna of Greenland, meagre though it is as yet known to be. No calcareous beds occur in either the miocene or cretaceous strata, and everything shews them to have been essentially of fresh-water origin.

A.—PLANTS.

FUNGI.

1. *Sphæria arctica*, Hr.	Fl. Foss. Arc. 86, tab. i., fig. 5.
2. *Sphæria annulifera*, Hr.	Fl. Foss. Arc. 86, tab. i., figs. 2-4.
3. *Rhytisma* (?) *boreale*, Hr.	Fl. Foss. Arc. 86, tab. i., fig. 1.

FERNS.

4. *Aspidium Meyeri*, Hr.	Fl. Tert. Helv. 1, p. 36, pl. xi., fig. 2; Phil. Trans. 1869, p. 461, pl. xxxix., figs. 1-3.
5. *Aspidium Heerii*, Ett.	Die Farrn Kräuter der Jetzwelt, p. 199; Heer, Phil. Trans. 1869, p. 462, pl. xxxix., figs. 4, 5.
6. *Aspidium ursinum*, Hr.	Phil. Trans. 1869, p. 462, pl. xxxix., fig. 6*a*.
7. *Woodwardites arcticus*, Hr.	Fl. Foss. Arc. 86, tab. i., fig. 16; tab. xlv., fig. 2*c*; tab. xlviii., fig. 9.

* Since writing this I have seen a paper in a popular journal, by Principal Dawson of Montreal, in which he ridicules the idea that a leaf, or even a fragment of a leaf, is not a perfectly ample material to identify a fossil species from, and he will even go so far as to say that it is quite as good a proof of the flora and other features of the country at the period it lived as the bones of a mammal its zoology. I fear that the learned and distinguished geologist quoted will have some difficulty in supporting such an assertion.

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8. *Lastræa* (*Phegopteris*) *Stircaca*, Hr.	Fl. Tert. Helv. 1, p. 31, tab. vii., viii.; Fl. Foss. Arc. 87, tab. xlv., fig. 7.
9. *Sphenopteris* (*Asplenium ?*) *Miertschingi*, Hr.	Fl. Foss. Arc. 87, tab. xlv., fig. 9*a*, *b*.
10. *Pteris æningensis*, A. Br.	Heer, Fl. Test. Helv. 1, p. 39; Fl. Foss. Arc., tab. xlv., fig. 8*a*.
11. *Pteris Rinkiana*, Hr.	Fl. Foss. Arc. 87, tab. i., fig. 12.
12. *Hemitelites Torellii*, Hr.	Fl. Foss. Arc. 86, tab. ii., fig. 15; I hil. Trans. 1869, pl. xl., figs. 1-5*a*; pl. lv., fig. 2.
13. *Osmunda Heerii*, Gaudin.	Heer, Fl. Tert. Helv. iii., p. 155; Phil. Trans. 1869, tab. i., figs. 6-11; tab. viii., fig. 156.

EQUISETACEÆ.

14. *Equisetum boreale*, Hr.	Fl. Foss. Arc. 89, tab. i., fig. 7; tab. xlv., fig. 10, 13*e*, *f*.

CONIFERÆ: CUPRESSINEÆ.

15. *Widdringtonia Helvetica*, Hr.	Fl. Tert. Helv. i., p. 48, pl. xvi., figs. 2, 18; Phil. Trans. 1869, pl. xli., figs. 10, 11; 10*b*, *c*.
16. *Taxodium distichum miocenum*, Hr.	Phil. Trans. 1869, p. 463, pl. xliii., figs. 4, 5. *Saxodium dubium*, Sternb., sp. Heer, Fl. Foss. Arc., p. 89.
17. *Glypstrobus Europæus*, Hr.	Fl. Tert. Helv. i., p. 51; iii., p. 51, tab. xix., xx., fig. 1. Fl. Foss. Arc., tab. iii., figs. 2, 5; tab. xlv., fig. 20, 32.
18. *Thujopsis Europæa*, Sap.	Saporta, Études sur la veg. du sud et de la France, a l'époque tertiare, ii., p. 184, tab. i., fig. 5; Heer, Fl. Foss. Arc., tab. l., fig. 11.
19. *Cupressinoxylon Breverni*, Merkl.	Cramer in Heer's Fl. Foss. Arc. 167, tab. xlii., figs. 11, 17.
20. *Cupressinoxylon ucranicum*, Gœpp.	Cramer in Heer's Fl. Foss. Arc. 168, tab. xxxiv., fig. 5; tab. xxxviii., figs. 7, 12.

ABIETINÆ.

21. *Sequoia Langsdorfii*, Hr.	Fl. Tert. Helv. i., p. 54; tab. xx., fig. 2; tab. xxi., fig. 4; Fl. Foss. Arc., tab. ii., figs, 2, 22; tab. xlv., figs. 13*a*, *c*, 14, 18; tab. xlvii., fig. 3*b*.
22. *Sequoia brevifolia*, Hr.	Fl. Foss. Arc. 93, tab. ii., fig. 23.
23. *Sequoia Couttsiæ*, Hr.	Bovey Tracey Lignite, p. 33, tab. viii., ix., x.; Fl. Foss. Arc., tab. iii., fig. 1; tab. viii., fig. 14; tab. xlv., fig. 19.
24. *Pinus hyperborea*, Hr.	Fl. Foss. Arc. 94, tab. xvii., fig. 5*f*.
25. *Pinus, sp.* Hr.	Fl. Foss. Arc., tab l., fig. 20.
26. *Pinus polaris*, Hr.	Fl. Foss. Arc. 157; Phil. Trans. 465, pl. xliii, fig 6.

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TAXINEÆ.

27. *Taxites Olriki*, Hr.	Fl. Foss. Arc. 95, tab. i., fig. 21-24*c*; tab. xlv., fig. 1*a*, *b*, *c*.
28. *Salisburea adiantoides*, Ung.	Phil. Trans. 1869, 465, pl. xliv., fig. 1; Fl. Foss. Arc. 95, tab. ii., fig. 1; xlvii. 4*a* (*S. borealis*, Hr).

GRAMINEÆ.

29. *Phragmites æningensis*, A. Br.	Heer, Fl. Tert. Helv. i., p. 64; Fl. Foss. Arc., tab. iii., figs. 6, 7, 8; tab. xlv., fig. 6.
30. *Poacites Mengeanus*, Hr.	Fl. Mioc. Balt., p. 59; pl. xv., figs. 2-11; Phil. Trans. 1869, p. 466, pl. lv., figs. 9, 10.
31. *Poacites, sp.*	Fl. Foss. Arc. 96, tab. iii., fig. 9.

CYPERACEÆ.

32. *Cyperites Zollikoferi*, Hr.	Fl. Tert. Helv., p. 76, tab. xxviii., fig. 4; Fl. Foss. Arc., tab. iii., fig. 12.
33. *Cyperites borealis*, Hr.	Fl. Foss. Arc. 96, tab. xlv., fig. 3.
34. *Cyperites microcarpus*, Hr.	Fl. Foss. Arc. 97, tab. xlv., figs. 4, 5.

SMILACEÆ.

35. *Smilax grandifolia*, Ung.	Sylloge Plantarum i., p. 7; Heer, Phil. Trans. 1869, pl. xlv., figs. 6*a*, 7.

TYPHACEÆ.

36. *Sparganium Stygium*, Hr.	Fl. Tert. Helv. iii., p. 101., tab. xlv., fig. 1.

NAIDACEÆ.

37. *Caulinites costatus*, Hr.	Fl. Foss. Arc. 467, pl. xliii., fig. 10.

LIQUIDAMBERACEÆ.

38. *Liquidamber Europæum*, A. Br.	Heer, Fl. Tert. Helv. ii., p. 6; Phil. Trans. 1869, pl. xli., fig. 13.

IRIDACEÆ.

39. *Iridium Grœnlandicum*, Hr.	Fl. Foss. Arc. 97, tab. iii., figs. 10, 11.

SALICACEÆ.

40. *Populus Richardsoni*, Hr.	Fl. Foss. Arc. 98, tab. iv., figs. 1-5; tab. vi., figs. 7, 8; tab. xv., fig. 1*c*.
41. *Populus Zaddachi*, Hr.	Fl. Mioc. Balt., pl. vi., fig. 3; Fl. Foss. Arc., tab. vi., figs. 1-4; tab. xv., fig. 1*b*.
42. *Populus Gaudinii*, Fischer.	Heer, Fl. Tert. Helv. ii., p. 24, tab. lxiv.; Fl. Foss. Arc., tab. vii., fig. 1-4; tab. l., fig. 9.

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43. *Populus sclerophylla*, Sap.	Lib. cit., tab. iv., pl. vi., fig. 13; Heer, Fl. Foss. Arc., tab. vii., fig. 5.
44. *Populus arctica*, Hr.	Fl. Foss. Arc. 100, tab. iv., figs. 6*a*, 7 tab. v.; tab. vi., figs. 5, 6; tab. viii figs. 5, 6; tab. xvii., fig. 5*b*, *c*.
Vars. a, b, c, d, and e.	
45. *Salix Grœnlandica*, Hr.	Fl. Foss. Arc., tab. iv., figs. 8, 9, 10.
46. *Salix Rœana*, Hr.	Fl. Foss. Arc., tab. iv., figs. 11-13; tab. xlvii., fig. 11.
47. *Salix varians*, Gœpp.	Heer, Phil. Trans. 1869, p. 469, pl. xliii., figs. 12, 13.

MYRICACEÆ.

48. *Myrica acuminata*, Ung.	Genera et Species Plant. Foss., p. 396; Heer, Fl. Foss. Arc., tab. iv., figs. 14-16; tab. vii., fig. 6*b*, *c*.
49. *Myrica borealis*, Hr.	Fl. Foss. Arc. 101, tab. xlvii., fig. 10.

BETULACEÆ.

50. *Betula Miertschengi*, Hr.	Fl. Foss. Arc. 103, tab. xii., fig. 9; tab. xlv., fig. 11*e*.
51. *Alnus nostratum*, Ung.	Chloris Protog., tab. xxxiv., fig. 1; Fl. Foss. Arc., tab. xlvii., fig. 12.

CUPULIFERÆ.

52. *Carpinus grandis*, Ung.	Iconog. Plant. Foss., p. 39; Heer, Fl. Foss. Arc., tab. xlix., fig. 9.
53. *Ostrya Walkeri*, Hr.	Fl. Foss. Arc. 103, tab. ix., figs. 9-12.
54. *Corylus insignis*, Hr.	Fl. Tert. Helv. ii., p. 43; Phil. Trans. 1869, pl. xlix., fig. 5.
55. *Corylus MacQuarrii*, E. Forbes.	Quart. Journ. Geol. Soc. 1851; Heer, Fl. Foss. Arc., tab. viii., figs. 9-12; tab. ix., figs. 1-8; tab. xvii., fig. 5*d*; tab. xix., fig. 7*c*.
56. *Fagus dentata*, Ung.?	Fossile Flora von Gleichenberg, p. 16, tab. ii., fig. 11; Heer, Fl. Foss. Arc., tab. x., figs. 1, 2, 7*b*, 9.
57. *Fagus macrophylla*, Ung.	Flora von Gleichenberg, p. 19, tab. ii. fig. 10; Heer, Fl. Foss. Arc., tab. xlvi., fig. 11.
58. *Fagus Deucalionis*, Ung.	Chloris Protog., p. 101; Heer, Fl. Foss. Arc., tab. viii., figs. 1-4; tab. x., fig. 6; tab. xlvi., fig. 4.
59. *Castanea Ungeri*, Hr.	Phil. Trans. 1869, p. 470; pl. xlv., figs. 1-3; tab. xlvi., fig. 8; Fl. Foss. Arc., tab. x., fig. 8; tab. xlvi., figs. 1, 2, 3. (*Fagus castanœfolia*, Ung.)
60. *Quercus Drymeia*, Ung.	Chloris Protog., p. 113, tab. xxxii., figs. 1-4; Heer, Fl. Foss. Arc., tab. xi., figs. 1-3.

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61. *Quercus furcinervis* Rossm., *sp.*	Rossmässler, Versteinerungen von Altsattel, p. 33, tab. vii.; Heer, Fl. Foss. Arc., tab. vii., figs. 6*a*, 7*a*; tab. xlv., fig. 1*d*; tab. xlvi., fig. 6.
62. *Quercus Lyellii*, Hr.	Bovey Tracey Lignite, p. 40, tab. xii., figs. 2-9, &c.; Fl. Foss. Arc., tab. xlvii., fig. 9.
63. *Quercus Grœnlandica*, Hr.	Fl. Foss. Arc., p. 108, tab. viii., fig. 8; tab. x., figs. 3, 4; tab. xi., fig. 4; tab. xlvii, fig. 1.
64. *Quercus Olafensi*, Hr.	Fl. Foss. Arc., p. 109; tab. x., fig. 5; tab. xi., figs. 7-11; tab. xlvi., fig. 10.
65. *Quercus platanea*, Hr.	Fl. Foss. Arc., p. 109, tab. xi. fig. 6; tab. xlvi., fig. 7.
66. *Quercus Steenstrupiana*, Hr.	Fl. Foss. Arc., p. 109, tab. xlvi., figs. 8, 9.
67. *Quercus* (*?*) *atava*, Hr.	Fl. Foss. Arc., p. 110, tab. ix., fig. 13*a*, *b*.
68. *Quercus Lahrpii*, Gaudin,	Contrib. à la Flora Fossile Ital. ii., p. 45, pl. iii., figs. 9, 10; Heer, Fl. Foss. Arc., tab. xliv., fig. 10; tab. xlix., figs. 2, 3, 4*a*.

ULMACEÆ.

69. *Planera Ungeri*, Ett.	Ettingshausen, Fl. Foss. von Wein, p. 14., tab. ii., figs. 5, 18; Heer, Fl. Foss. Arc., tab. ix., fig. 8*b*.

MORACEÆ.

70. *Ficus* (*?*) *Grœnlandica*, Hr.	Fl. Foss. Arc., p. 111, tab. xiii., fig. 6.

PLATANACEÆ.

71. *Platanus aceroides*, Göpp.	Heer, Fl. Foss. Arc., p. 111, tab. xlvii., fig. 3.
72. *Platanus Guillelmæ*, Göpp.	Tert. Fl. von Schossnitz, p. 21, pl. xi., figs. 1, 2; Heer, Fl. Foss. Arc., tab. xii. (*P. aceroides*, var.)

LAURACEÆ.

73. *Sassafras Ferretianum*, Massal.	Studii Sulla Flora Fossile Senegaghense, p. 268, pl. xii., figs. 1, 2, 3; Heer, Phil. Trans. 1869, pl. l., figs. 1, 2.
74. *Daphnogene Kanii*, Hr.	Fl. Foss. Arc., tab. xii.; tab. xvi., fig. 1.

PROTEACEÆ.

75. *Hakea* (*?*) *arctica*, Hr.	Fl. Foss. Arc., p. 113, tab. xv., figs. 5, 6.
76. *Dryandra acutiloba*, Brogn.	Ettingshausen, Fossile Proteaceæ, pl. iv., figs. 2, 3; Heer, Phil. Trans. 1869, pl. xxxix., fig. 7.

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MENISPERMACEÆ.

77. *M'Clintockia Lyellii*, Hr.	Fl. Foss. Arc., p. 115, pl. xv., figs. 1*a*, 2; xvi., 7*a*, *b*; xvii., 2*a*, *b*; xlvii., 13; xlviii., 8.
78. *M'Clintockia dentata*, Hr.	Fl. Foss. Arc., p. 115, pl. xv., fig. 34.
79. *M'Clintockia trinervis*, Hr.	Fl. Foss. Arc., p. 115, pl. xv., figs. 7-13.

ERICACEÆ.

80. *Andromeda protogæa*, Ung.	Flora von Solzka, tab. xxiii., fig. 2; Heer, Fl. Foss. Arc., tab. xvii., figs. 5*a*, 6.
81. *Andromeda denticulata*, Hr.	Fl. Foss. Arc., p. 116, tab. l., fig. 11*d*, *e*.
82. *Andromeda Saportana*, Hr.	Fl. Foss. Arc., p. 117, tab. xvii., fig. 7.

CAPRIFOLIACEÆ.

83. *Viburnum Whymperi*, Hr.	Phil. Trans. 1869, pl. xlvi., fig. 1*b*.

EBENACEÆ.

84. *Diospyros brachysepala*, A. Br.	Heer, Fl. Tert. Helv. iii., p. 11; Fl. Foss. Arc., tab. xv., figs. 10-12; xvii., 5*h*, *i*; xlvii., 5-7.
Var. *b*, *longifolia*, Heer,	Fl. Tert. Helv. iii., p. 12.
85. *Diospyros Loveni*, Hr.	Fl. Foss. Arc., p. 118, tab. vii., figs. 7, 8; xlvii., fig. 8.

GENTIANACEÆ.

86. *Menyanthes arctica*, Hr.	Fl. Foss. Arc., p. 118, tab. xvi., figs. 2, 3.

OLEACEÆ.

87. *Fraxinus denticulata*, Hr.	Fl. Foss. Arc., p. 118, tab. xvi., fig. 4.

RUBIACEÆ.

88. *Galium antiquum*, Hr.	Fl. Foss. Arc., p. 119, tab. xvii., fig. 8.

ARALIACEÆ.

89. *Aralia* (*Sciadophyllum?*) *Brownii*, Hr.	Phil. Trans. 1869, pl. xlii., figs. 6-8; xlix., 4*c*.
90. *Hedera MacClurii*, Hr.	Fl. Foss. Arc., p. 119, tab. xvii., figs. 1*a*, 2*c*, 3, 4, 5*a*.

CORNACEÆ.

91. *Cornus ferox*, Ung.	Sylloge Plant. Foss., p. 76, tab. xxiv., fig. 21.
92. *Cornus hyperborea*, Hr.	Phil. Trans. 1869, p. 476, pl. l., figs. 3, 4.
93. *Nyassa arctica*, Hr.	Phil. Trans. 1869, p. 477, pl. xliii, fig. 12*c*; l., 5, 6, 7, 6*b*.

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VITACEÆ.

94. *Vitis Olriki*, Hr.	Fl. Foss. Arc., p. 120, tab. xlviii., fig. 1.
95. *Vitis arctica*, Hr.	Fl. Foss. Arc., p. 120, tab. xlviii., fig. 2.

MAGNOLIACEÆ.

96. *Magnolia Inglefieldi*, Hr.	Fl. Foss. Arc., p. 120, tab. iii., fig. 5*c*; tab. xvi., figs. 5, 6, 8*b*; tab. xviii., figs. 1-3.

MYRTACEÆ?

97. *Callistemophyllum Moorii*, Hr.	Fl. Foss. Arc., p. 121, tab. xviii., figs. 4, 5.

STERCULIACEÆ? (BUTTNERIACEÆ?).

98. *Pterospermites spectabilis*, Hr.	Phil. Trans. 1869, p. 480, pl. xliii., fig. 156; liii., fig. 1-4.
99. *Pterospermites alternans*, Hr.	Phil. Trans. 1869, p. 480, pl. liv., fig. 3.
100. *Pterospermites integrifolius*, Hr.	Phil. Trans. 1869, p. 122, tab. ix., fig. 14*a*.

ACERACEÆ.

101. *Acer otoplerix*, Göpp?	Heer, Flor. Foss. Arc., p. 122, tab. l. fig. 10.

RHAMNACEÆ.

102. *Paliurus Colombi*, Hr.	Fr. Foss. Arc., p. 122, tab. xvii., fig. 2*d*; tab. xix., figs. 2-4.
Var. *b*, pl. xli., fig. 12.	
103. *Paliurus* (?) *borealis*, Hr.	Fl. Foss. Arc., tab. xix., fig. 1.
104. *Zizyphus borealis*, Hr.	Fl. Foss. Arc., p. 123, tab. xlix., fig. 2.
105. *Rhamnus Eridani*, Ung.	Flora von Sotzka, p. 53, tab. xxxvii., figs. 1-5; Fl. Foss. Arc., tab. xix, figs. 5, 6, 7*a*; tab. xlix., fig. 10.
106. *Rhamnus brevifolius*, A. Br.	Heer, Fl. Tert. Helv. iii., p. 78, tab. cxxiii.; Fl. Foss. Arc., tab. xlix., fig. 1.
107. *Rhamnus Gaudini*, Hr.?	Fl. Tert. Helv. iii., p. 79, tab. cxxiv., figs. 4-15; Fl. Foss. Arc., tab. l., fig. 6.

AQUIFOLEACEÆ.

108. *Ilex longifolia*, Hr.	Fl. Foss. Arc., p. 124, tab. xlviii., figs. 3-5.
109. *Ilex* (?) *reticulata*, Hr.	Fl. Foss. Arc., p. 124, tab. xlviii., fig. 7.
110. *Ilex macrophylla*, Hr.	Phil. Trans. 1869, p. 481, pl. xliv., fig. 11*b*; lvi., fig. 2.

CELASTRACEÆ.

111. *Euonymus amissus*, Hr.	Phil. Trans. 1869, p. 481, pl. lvi., fig. 10*b*.

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JUGLANDACEÆ.

112. *Juglans acuminata*, A. Br.	Heer, Fl. Tert. Helv. iii., p. 88, tab. cxxviii. and cxxix.; Fl. Foss. Arc., tab. vii., fig. 9; tab. xii., fig. 1*b*; tab. xlix., fig. 7.
113. *Juglans denticulata*, Hr.	Phil. Trans. 1869, p. 483, pl. lvi., figs. 6-9.
114. *Juglans paucinervis*, Hr.	Fl. Foss. Arc., tab. xix., fig. 8.
115. *Juglans Strozziana*, Gaud.	Heer, Fl. Foss. Arc., tab. xlix., figs. 3-6.

ANACARDIACEÆ.

116. *Rhus bella*, Hr.	Phil. Trans. 1869, p. 482, pl. lvi., fig. 3-5.
117. *Rhus arctica*, Hr.	Phil. Trans. 1869, p. 482, pl. xl., fig. 5*e*, *e*.

ROSACEÆ.

118. *Sorbus grandifolia*, Hr.	Phil. Trans. 1869, pl. liv., fig. 4.
119. *Cratægus antiqua*, Hr.	Fl. Foss. Arc., p. 125, tab. l., figs. 1, 2.
120. *Cratægus Warthana*, Hr.	Fl. Foss. Arc., p. 126, tab. l., figs. 3, 4.
121. *Prunus Scottii*, Hr.	Fl. Foss. Arc., p. 126, tab. viii., fig. 7.

LEGUMINOSÆ.

122. *Colutea Walteri*, Hr.	Fl. Tert. Helv. iii., p. 101, tab. cxxxii. figs. 45-57.
123. *Leguminosites arcticus*, Hr.	Fl. Foss. Arc., p. 127, tab. l., fig. 5.
124. *Leguminosites, sp.*	Phil. Trans. 1869, pl. xxxix., fig. 3*b*.
125. *Carpolithes cocculoides*, Hr.	Phil. Trans. 1869, p. 484, pl. lii., figs. 9, and 9*b*.
126. *Carpolithes Potentilloides*, Hr.	Phil. Trans. 1869, p. 484, pl. xliii., figs. 11*b* and 11*c*.
127. *Carpolithes bicarpellaris*, Hr.	Fl. Foss. Arc., p. 129, tab. xvi., figs. 15 and 15*b*.
128. *Carpolithes follicularis*, Hr.	Phil. Trans. 1869, p. 484, pl. l., figs. 14, 15.
129. *Carpolithes lithospermoides*, Hr.	Fl. Foss. Arc., p. 128, tab. xvi., figs. 11, 12, 14.
130. *Carpolithes sulculatus*, Hr.	Phil. Trans. 1869, p. 484, pl. lvi., figs. 11 and 11*b*.
131. *Carpolithes symplocoides*, Hr.	Fl. Foss. Arc., p. 128, tab. xvi., fig. 8*a*.
132. *Carpolithes pusillimus*, Hr.	Phil. Trans. 1869, p. 484, pl. lvi., figs. 12 and 12*b*.
133. *Carpolithes sphærula*, Hr.	Fl. Foss. Arc., p. 128, tab. xv. fig. 10.

INCERTA SEDIS.

134. *Phyllites Liriodendroides*, Hr.	Fl. Foss. Arc., p. 127, tab. iii., fig. 5*d*.
135. *Phyllites membranaceus*, Hr.	Fl. Foss. Arc., p. 127, tab. xix., fig. 9.
136. *Phyllites evanescens*, Hr.	Fl. Foss. Arc., p. 127, tab. l., fig. 7.
137. *Phyllites Rubiformis*, Hr.	Fl. Foss. Arc., p. 127, tab. xix., figs. 10-12; tab. xvi., fig. 8*c*.

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B.—ANIMALS.

INSECTS: COLEOPTERA.

1. *Trogosita insignis*, Hr.	Fl. Foss. Arc., p. 29, tab. l., figs. 12*a*, 12*b*.
2. *Chrysomelites Fabricii*, Hr.	Fl. Foss. Arc., p. 129, tab. xix., figs. 13, 14.
3. *Cistelites punctulatus*, Hr.	Phil. Trans. 1869, p. 484, pl. lvi., figs. 14, 14*b*, and 14*c*.
4. *Cercopedium rugulosum*, Hr.	Phil. Trans., 1869, p. 485, pl. xliv., figs. 9*b*, and 9*b*, *b*.

ORTHOPTERA.

5. *Blattidium fragile*, Hr.	Fl. Foss. Arc., p. 13, tab. l., figs. 13, 13*b*.

RHYNCHOTA.

6. *Pentatoma boreale*, Hr.	Fl. Foss. Arc., p. 130, tab. xix., figs. 15, 15*b*.

MOLLUSCA.

7. *Cyclas, sp.* Hr.	Phil. Trans. 1869, p. 485, pl. lii., figs. 10, 10*b*.

VII.—List of the Cretaceous Flora of Greenland.

FERNS.

1. *Sphenopteris* (*Asplenium*) *Johnstrupi*, Hr.	Fl. Foss. Arc, 76, tab. xliii., fig. 7.
2. *Gleichenia Gieseckiana*, Hr.	Fl. Foss. Arc. 76, tab. xliii., figs. 1*a*, 2*a*, 3*a*; tab. xliv., figs. 2, 3.
3. *Gleichenia Zippei*, Corda,	Versteinerungen der Kreideformation, 595, tab. xlix., fig. 1; Heer, Fl. Foss. Arc., tab. xliii., fig. 4.
4. *Gleichenia Rinkiana*, Hr.	Fl. Foss. Arc. 80, tab. xliii., fig. 6.
5. *Gleichenia rigida*, Hr.	Fl. Foss. Arc. 80, tab. xliv., fig. 1.
6. *Pecopteris arctica*, Hr.	Fl. Foss. Arc., tab. i., fig. 13; tab. xliii., fig. 5.
7. *Pecopteris borealis*, Brongn.	Hist. des Veget. Fossil. i., 351, tab. cxix., fig. 1; Heer, Fl. Foss. Arc., tab. xliv., fig. 5 *a*, *b*.
8. *Pecopteris hyperborea*, Hr.	Fl. Foss. Arc., tab. xliv., fig. 4.
9. *Danæites firmus*, Hr.	Fl. Foss. Arc., tab. xliv., figs. 20-22.
10. *Sclerophyllina dichotoma*, Hr.	Fl. Foss. Arc., tab. xliv., fig. 6.

CYCADACEÆ.

11. *Zamites arcticus*, Göpp.	Jahrbuch für Mineral. Geol. und Palæont. 1866, p. 134, tab. ii., figs. 9, 10; Heer, Fl. Foss. Arc., tab. xliv., fig. 5*c*.

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CUPRESSINEÆ.

12. *Widdringtonites gracilis*, Hr.	Fl. Foss. Arc. 83, tab. xliii., figs. 1*e*, 3*c*, &c.

ABIETINEÆ.

13. *Sequoia Reichenbachii*, Gein.	*Sp.*, Charakeristics des Sächs-böhm, Kreidegebirges, 98, tab. xxiv., fig. 4. Heer, Fl. Foss. Arc., tab. xliii., figs. 1*d*, 2*b*, 5*a*.
14. *Pinus Peterseni*, Hr.	Fl. Foss. Arc. 84, tab. xliv., fig. 19.
15. *Pinus Crameri*, Hr.	Fl. Foss. Arc. 84, tab. xliv., figs. 7-18.

MONOCOTYLEDON.

16. *Fasciculites Grœlandicus*, Hr.	Fl. Foss. Arc. 85, tab. xliv., fig. 23.

I have, as yet, seen no detailed account of the collections made by Professor Nordenskjöld and his companions, but in a brief list recently published by the Swedish Academy,* I found the following species of miocene plants, not hitherto known from previous collections, mentioned by Professor Heer, but without descriptions, and under M.S. names:—

Pteris Sitkensis, Hr.	From Iglosungoak, Disco I.
Polyporites Sequoia, Hr. M.S.	,, Netluarsuk, Noursoak.
Muscites subtilis, Hr. M.S.	,, ,, ,,
Biota borealis, Hr. M S.	,, ,, ,,
Sequoia Nordenskjöldii, Hr. M.S.	,, ,, ,,
S. Sternbergi, Göpp.	,, ,, ,,
Eleaginus arcticus, Hr. M.S.	,, ,, ,,
Nyssidium Grœnlandicum, Hr. M.S.	,, ,, ,,
Sclerotum Cinnamomi, Hr.	From Ifsorisak.
Sphenopteris Blomstrandi, Hr.	,, ,,
Taxites validus, Hr.	,, ,,
Carex Noursoakensis, Hr. M.S.	,, ,,
Smilax lingulata, Hr.	From Asakak.
Sclerotum populicola, Hr.	From Siuifik.
Cyperus Sinifikiana, Hr. M.S.	,, ,,
Poacites Nielseni, Hr. M.S.	From Piulasok.
Potamogeton Rinkii, Hr. M.S.	,, ,,
,, *dubius*, Hr. M.S.	,, ,,
Salix linga, A. Br.	,, ,,
,, *tenera*, A. Br.	,, ,,
Myrica lingulata, Hr. M.S.	,, ,,
,, *grosseserrata*, Hr. M.S.	,, ,,
Daphne persooniæformis, D. Webb.	,, ,,
Aristolochia borealis, Hr. M.S.	,, ,,

* "Om de Miocena Vaxter, som den Svenska Expeditionen, 1870, hemfört fran Grönland," af Oswald Heer. (*Ofversigt af Kongl. Vetensk.—Akad. Forh.* 1873, No. 10).

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Andromeda Narbonensis, Sap.	From Piulasok.	
Dospyrus Lovenii, Hr.	"	"
Acerates veterana, Hr.	"	"
Apeibopsis Nordenskjoldi, Hr. M.S.	"	"
Celastrus firmus, Hr.	"	"
Leguminosites longipes, Hr. M.S.	"	"

VIII.—Former Range of the Miocene Flora of Greenland.

We have seen that the Greenland miocene flora is only now found in a very limited district in North Greenland. There seems, however, every reason to believe that during the miocene epoch it was much more extensively distributed, and that instead of the miocene forests only being found in the vicinity of Disco Island, these deposits are but the fragmentary remains of much more extensive deposits which at one time stretched over the whole continent of Greenland, as well as other parts of the Arctic regions. In localities so distant from each other as Spitzbergen and Mackenzie River, we find plants of this era identical in species, and the floras of both do not differ more widely from that of Greenland than might be expected of recent floras extending over so wide an area. In fact the flora of Spitzbergen and Greenland differs as widely now as do their fossil miocene floras, so far as the materials obtained enable us to judge.* Until this year we only knew the miocene strata in Greenland as existing in the localities so repeatedly mentioned and described in the foregoing pages. But, as early as 1822 the celebrated William Scoresby obtained some fossil plants from the east coast, which were, however, lost before being submitted to scientific examination; and, accordingly, the re-collection of these has been always a desideratum in science. This has been supplied within the last few years, for since this paper was first written, the second German polar expedition has returned, and among the noble additions to science and the story of adventure which it brings to us, not the least interesting and valuable is a large collection of miocene plants from the east coast of Greenland.† These plants, when examined, will doubtless fill

* Heer in *Bibl. Univ.*, 1869, *l.c.*, and Om de af A. E. Nordenskjöld och C. W. Blomstrand pä Spetsbergen upptäckta fossila vexter in *Ofversigt af Kongl. Vetenskaps-Akademiens Förhandlingar*, 1866, No. 6; and his *Flora Fossilis Arctica*, or its French translation, *Flore fossile des régions polaires*, p. 61, *et seq.*

† I derive this information from an official Report issued by the Bremen Committee ("Zweite deutsche Nordpolarfahrt," No. viii.) in advance of the

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an immense gap in our knowledge of the distribution of the miocene flora in Greenland, and go far to shew that at one time this flora extended right over the continent, but that the soft deposits in which its remains were entombed have either been covered by the great continental ice, or denuded by submergence, by weather, or by the immense masses of ice which seem at one time to have ground over almost every portion of the Greenland continent. The distribution of this flora is one of the most interesting of all subjects in Arctic geology, and it is on the east coast of Greenland—unfortunately almost inaccessible, and rarely visited—that we must look for the chief additions to our knowledge of that subject. Not only was the Greenland miocene flora closely allied to that of Spitzbergen and Mackenzie River,* but it was also nearly connected with that of Europe; according to Heer, 46 out of 137 species found in Greenland being identical with European species—6 of these extending as far as the coast of the Baltic, 10 as far as Switzerland, 7 as far as Austria, 4 as far as France (Armissau and Menat), 17 to Italy, and 6 to Greece. Four species are common to North Greenland and Bovey Tracey in Devonshire. Among these is the tree most common in the latter locality—*Sequoia Couttsiæ*, while the fern most frequently found at Bovey Tracey (*Hemitelites lignitum*) is represented in Greenland by a closely allied congener (*H. Torrellii*, Hr.) It will be seen from what I have stated, that in the study of the fossil flora of the Arctic regions, a most interesting and comparatively little worked subject lies open to an enterprising and properly trained explorer.

IX.—Description of the Map.

The map accompanying this paper is based on that of Rink, who has incorporated the surveys of all previous explorers, with some corrections of the coast line from the map of Rohde and Steenstrup, and my own observations. The latitudes of the settlements around Disco Bay are from my own observations (meridian altitudes of the sun), the longitudes chiefly after Nordenskjöld,

great work on this expedition now publishing, which will contain full accounts of the geological observations and discoveries of the expedition.

* This was written in 1868. Since then the statistics of the Arctic miocene flora stands as follows:—The whole number of species known is 321. Of these 167 are Greenland, 80 of these were found by us, 32 were new to the Greenland flora, and 20 were entirely new to science.

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Graah, and other authorities. The geological details are by myself, as narrated in the text. Only those parts are coloured geologically of which the general lithology is known. In most cases, the limits of the formations can only be given approximately. It must be understood that where miocene and cretaceous formations are marked as existing, that there are also, as described, outbursts of trap, &c.; but the trap, for the sake of clearness of detail, is marked as existing *behind* the sedimentary rocks.

VII.—Notes *on the recent* Ostracoda *and* Foraminifera *of the* Firth of Clyde, *with some remarks on the Distribution of Mollusca.* By David Robertson, F.G.S.

[Read 16th April, 1874.]

A paper on recent Ostracoda and Foraminifera may seem rather out of place before a Geological Society, as communications of this kind usually find their way into other channels specially prepared for them. But when we consider the close relation of the present with the past, we perceive that much light may be thrown on the fossil fauna by a knowledge of the life-habits of existing forms; and no classes of animals are better fitted for this purpose than our minute Ostracoda and Foraminifera, extending as they do through all geological formations, and abounding in all seas and at all depths.

Keeping in view the geological bearing of the facts, I propose to bring forward some particulars with regard to the variations in the groupings of species in different habitats and different localities, taking into account the depth of water and the character of the sea-bottom, together with the occurrence of species in one place compared with another, and their relative abundance or rarity.

In drawing conclusions from the condition of the sea-bottom, we must remember that different groupings may be met with in mud, sand, or gravel of similar appearance, and often at no great distance from each other. Apparently slight differences in the constituents, chemical condition, &c., of the sea-bottom will account, in a great measure, for the absence or sparseness of a given species in one locality, and its abundance in another.

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However similar the habitat of a species may be at the bottom of the sea in one place as compared with another, a little difference of the materials of which it is composed, although that difference is quite inappreciable to the eye, may favour the increase of size, or impoverish and check reproduction. Such difference in the habitat may also give different degrees of intensity and modes of arrangement to the colours and sculpturings, and so produce and develop varieties.

In many cases, there appears to be too much readiness to adduce climatal change as a cause of varieties in the fauna, which may be only the consequence of local circumstances. For example, *Terebratula caput-serpentis* (an Arctic species) is large, well grown, and abundant in Lochfyne, but small, dwarfed, and rare at Cumbrae—at both places in the same depth of water and on similar bottoms, which obviously must be attributable to some unobserved conditions of habitat, independent of climate. There is another curious fact with regard to *Terebratula caput-serpentis*, in common with a few other species—namely, that it is abundant in the Norwegian post-tertiary clays, and rare or absent in those of Scotland, while yet it is a common recent species in the Scottish seas. If temperature were the sole agency which regulated the distribution of species, we might expect to find the remains of nearly all our existing species becoming more abundant in our recent clays, as they approach to the present epoch.

Astarte borealis, on the other hand, is an Arctic type not living in our British seas, but common in many of our Scottish post-tertiary deposits. It is remarkable, however, that of forty-six glacial and post-glacial deposits examined by the late Professor M. Sars, in only one of these was *Astarte borealis* obtained. Reasoning on the climatal hypothesis of transmission, we should infer that *Astarte borealis* would be much more common in the Norwegian than the Scottish deposits; yet the reverse is the case: which might raise the question naturally enough, whether this so-called Arctic species really came from the north to our seas during the glacial period, as seems to be the common opinion, or whether it has not made its way from our seas to its present northern habitat.

On the east coast of Scotland, the post-tertiary fauna has been considered more intensely Arctic than that in the valley of the Clyde on the west; but whatever the cause may have been, it cannot well be attributed to a difference of climate, as, at the

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time these beds of shell-bearing clay were deposited, the same seas must have flowed freely between the Firth of Forth and the Firth of Clyde. In drawing inferences from the extreme temperatures of cold that prevailed over the country in glacial times, we are apt not to take sufficiently into account the great difference of range between subaerial and subaqueous temperatures. As the cold never attains in any sea to more than a few degrees below the freezing point of fresh water, it would seem to follow that we cannot reasonably attribute so much influence to the cold in affecting or changing the character of the fauna of our seas, as is frequently assigned to it.

It has been shewn that it is quite a common thing for existing species of the invertebrate fauna to be abundant in one locality and wanting at another at no great distance, where all the conditions appear to be similar; and these anomalies of distribution often remain with great constancy. It would obviously be unwarrantable to conclude that these variations of animal life on different portions of the same sea-bottom were brought about by change of climate.

Abundance or rarity of animal life, both of recent and in older deposits, are and have been (there can be no doubt) largely influenced by the depth of water, the strength and temperature of currents, and the condition of the sea-bottom,—whether it affords the most suitable habitat, or supplies the food best fitted for the healthy development of the species, and what measure of immunity the adult or young enjoy from their enemies. Such circumstances must go far to regulate the dispersion of the invertebrate fauna over the sea-bottom.

In this country, we are in the habit of testing the Arctic character of our glacial shells by the presence or absence of recent species; that is, if a post-tertiary British species is not found living in our present seas, but living in Arctic regions, the conclusion come to is, that the species is of Arctic origin, and had been ushered in with the cold from northern regions, and with the cold had retired back to its former locality. *Pecten Islandicus* is a common type of this character—an abundant shell in the post-tertiary deposits of the valley of the Clyde—and its large dimensions in many of the beds shew that it had lived under most favourable conditions. But how or under what circumstances this species performed the migration from Arctic regions to our latitude and back, may be difficult to say.

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The migration of some species of Mollusca from one distant sea to another is full of interest, but their mode of transport is encompassed with much uncertainty. For example, the late Professor Sars remarked that *Tapes decussata* (Linn.) and *Pholas candida* (Linn.) are found in the post-glacial clays of Norway, though not now living on the shores of that country, so far as known; such cases are thought to be the relics of ancient communications between different seas. The difficulty in such cases is to see how a littoral Mollusc could make its way, or propagate by degrees, across hundreds of miles of deep-sea bottom presenting conditions inconsistent with the requirements of food and habitat of a littoral species. Even the deep-sea species in these long migrations might find extensive parts of shallow ooze, sand, or gravel, together with variations of temperature, offering insurmountable barriers to their progress. Still, in spite of all these obstacles, such migrations seem to have taken place.

On comparing the recent Ostracoda and Foraminifera of the Clyde district with those of post-tertiary age, we find that from thirty-five different localities of recent Ostracoda, the average gross number is 34, the lowest number from any one locality being 22, and the highest 50.

The average number of post-tertiary Ostracoda from twenty different localities is 23, the lowest being 10, and the highest 37.

The average number of recent Foraminifera from seventeen localities is 37, the lowest from any one locality 27, the highest 50.

From ten post-tertiary deposits the average number of species of Foraminifera is 17, the lowest 9, and the highest 30.

These results may be tabulated as under:—

OSTRACODA.

Post-Tertiary (twenty localities).		Recent (thirty-five localities).	
Average,	23	Average,	34
Highest,	17	Highest,	50
Lowest,	10	Lowest,	22

FORAMINIFERA.

Post-Tertiary (ten localities).		Recent (seventeen localities).	
Average,	17	Average,	37
Highest,	30	Highest,	50
Lowest,	9	Lowest,	27

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From these comparisons it is seen that the recent Ostracoda and Foraminifera in the valley of the Clyde exceed considerably those of post-tertiary deposits—fully one-third in the Ostracoda, and one-half in the Foraminifera. Whatever the cause may have been of so marked a difference in numbers, we can scarcely ascribe much of it to erosion, since the most delicate sculpture remains beautifully sharp and distinct over the calcareous tests of these minute organisms, notwithstanding their long entombment in the clays of our country.

So far as our investigations have gone, both fossil Ostracoda and Foraminifera are less numerous in the clays on the east of Scotland than on the west. From ten deposits—Dryleys, Puggeston, Annochie, Barrie, Errol, King Edwards, Gamrie, Elie, Wick, and Burn of Haster—the average number of Ostracoda is 13; the lowest 6, and the highest 23. The average number of Foraminifera from seven deposits—Dryleys, Puggeston, Elie, Errol, Gamrie, and King Edwards—is 15; the lowest 8, and the highest 28. Thus—

The average fossil Ostracoda on the west is 23, on the east, 13.
" " Foraminifera, " 17, " " 15.

the chief difference being confined to the Ostracoda.

So far as the localities that have been examined indicate, the post-tertiary Ostracoda on the west of Scotland exceed the Foraminifera by nearly one-third, while in the east the Foraminifera slightly exceed the Ostracoda.

In seven Norwegian post-glacial deposits, the average number of Ostracoda is 14, the lowest in any one locality is 9, and the highest 19. The average number of Foraminifera is 19, the lowest 12, and the highest 31. Here the Foraminifera exceed the Ostracoda in their average number of species by nearly one-third, while in the west of Scotland the Ostracoda exceed the Foraminifera to an equal extent.

Further research may change these proportions to some extent, but it is most likely that the general results will remain nearly the same; and there is little reason to suspect fallacy connected with the manner in which the samples were collected for examination, as the quantity of material examined from each locality was nearly the same—the chief difference being that a few gatherings from the recent localties were more gravelly than our brick clays are—a prevailing feature in the

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laminated clays of the Clyde district being that they are composed of fine clays interstratified by thin layers of sand, with stones of various sizes thinly interspersed, many of them scratched and grooved, and occasionally covered by the remains of Balani and Serpulæ—the stones, great and small, seldom exceeding nine or ten per cent.

All post-tertiary deposits within the reach of the tide have been excluded, as they would greatly vitiate such comparison, being at all times unavoidably mixed with recent organisms.

There is another fact connected with the distribution of these minute organisms worthy of notice, which is, the great influence that the depth of water appears to have upon the relative proportion of Ostracoda and Foraminifera. In the greatest depths reached by the "Porcupine" and the "Challenger," Foraminifera were found with an entire absence of Ostracoda. I have lately had the opportunity of examining a large number of parcels of material dredged by Mr. Whiteaves in the Gulf of St. Lawrence. In eight of these gatherings, the least depth was 120 fathoms, the greatest depth 313 fathoms, and the average 196 fathoms. In all of these, there is a remarkable scarcity of Ostracoda; in some they are wholly absent, and in others there is only one species, represented by one or two individuals. In some of the other gatherings, there might be two or three species, but in most cases one species only was found, and generally limited to a few individuals. In the same gatherings, Foraminifera are in great abundance, both in genera, species, and individuals. It may be remarked, however, as might be expected, that the decrease of Ostracoda does not strictly follow the increase of depth, for in different localities at the same depth, the proportions of these Ostracoda vary considerably, and also relatively to the Foraminifera, arising, we may reasonably assume, from local causes.

There is yet another remarkable fact connected with these tiny forms—one that we might not readily suspect—viz., that they are in greater abundance in many places exposed to the wild tumults of the sea, than they are in our sheltered lochs. In five of these—Lochfyne, Lochlong, Loch Striven, Loch Ridden, and Loch Ryan—the average number of Ostracoda is 28, against 34 of the general average. The average number of Foraminifera in three lochs—Loch Striven, Loch Ridden, and Loch Ryan—is 29, against 37 species of the general average.

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Perhaps the richest haul we have had in the Firth of Clyde was on the exposed coast between Ardrossan and Portincross, about three miles off shore, in thirty fathoms, mud bottom. The Ostracoda numbered 43 species, and the Foraminifera 62, which is about one-half of the British marine Foraminifera obtained in this one haul.

The great number of Ostracoda and Foraminifera that may be collected from a small parcel of mud, dredged from a very circumscribed spot, shews the vast abundance of these minute animals that swarm over the bottom of the sea.

In preparing this catalogue of the marine Ostracoda and Foraminifera of the Firth of Clyde, I include all the tract between a line drawn from the west shore of Loch Ryan to the Mull of Kintyre on the south, and Dumbarton Castle on the north. Not that all this extent has been thoroughly wrought out, but that the gatherings might be from as many distinct points as the district would admit of.

It is not to be understood that more than a haul here and there has been taken at distant points, except in the neighbourhood of the Cumbraes, where more opportunities have occurred of working over a closer succession of points. Nor are the various lists made within these bounds to be viewed as in any sense exhaustive, but only what may have been taken in a single haul;—another gathering at a very short distance might add considerably to the list.

The object aimed at is chiefly to shew how the groupings of the species vary at different places, on different bottoms, and at different depths, which could only be done with any degree of accuracy by confining the lists to one haul, which reduces the risk of mixing two different characters of sea-bottom to a minimum. This object was further secured by the construction of the dredge that was used, which generally filled by dragging it a few boat-lengths.

The appended Tables shew at a glance the relative proportions of both Ostracoda and Foraminifera, as thus obtained over the area described.

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OSTRACODA.

REMARKS ON THE SPECIES.

PARACYPRIS POLITA, G. O. Sars.

Paracypris polita, G. O. Sars. Overs. Nory. Mar. Ostrac., p. 12.
" " Brady. Monog. Rec. Brit. Ostrac., p. 378.

DISTRIBUTION—*Recent:* Norway, Great Britain. *Fossil:* Scotland—Raised beach, Oban. Norway, post-tertiary beds.

In the Clyde district this species may be considered rare, or confined to patches. In the forty gatherings given in the Table, it occurs only in five—in two rare, and in three moderately common, in none abundantly.*

PONTOCYPRIS MYTILOIDES, Norman.

Cythere mytiloides, Norman. Ann. Mag. Nat. Hist., vol. ix., p. 50.
Pontocypris mytiloides, Brady. Monog. Rec. Brit. Ostrac., p. 385.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland. *Fossil:* Scotland—Dumbarton, Cartsdyke, Paisley; Dipple; Norway.

This species occurs in twenty-six of the gatherings represented in the annexed Table—in twelve it is rare, and in fourteen moderately common, but nowhere found in any great abundance in the Clyde district. Its range is from 6 to 30 fathoms. As a fossil it is more common in silts and raised beaches than in the post-tertiary deposits or those containing Arctic shells. It may be remarked that the young of this species, at an early stage of their growth, assume the adult form; and the colour of the adult shell belongs to the shell itself, and not, as in many cases, where it is only the animal tissues seen through the shell.

PONTOCYPRIS TRIGONELLA, G. O. Sars.

Pontocypris trigonella, G. O. Sars. Overs. Nory. Mar., p. 16.
" " Brady. Monog. Rec. Brit. Ostrac., p. 387.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland, Mediterranean, Cape Verde. *Fossil:* Lochgilp, Paisley, Cartsdyke, Dipple.

Occurs in fourteen out of the forty gatherings from the Clyde district—in eight it is rare and in six moderately common, but does not prevail in any. It is found equally common in raised beaches and post-tertiary deposits.

ARGILLÆCEA CYLINDRICA, G. O. Sars.

Pontocypris angusta, Brady. Monog. Rec. Brit. Ostrac., p. 387.

DISTRIBUTION—*Recent:* Great Britain, Norway. *Fossil:* Scotland—Duntroon, Cartsdyke, Paisley, Dalmuir, Dumbarton.

* Rarity or abundance refers only to the gathering to which it belongs, and not to the district, as a species may be rare in one gathering and common in another in the same locality.

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This species occurs only in four of the forty gatherings—in three rare, and in one moderately common. It is more common in the post-tertiary clays than silts or raised beaches.

BAIRDIA INFLATA, Norman.

Cythere inflata, Norman.	Ann. & Mag. Nat. Hist., vol. ix. p. 49.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 388.

DISTRIBUTION—*Recent:* Great Britain, Ireland. *Fossil:* Scotland—Raised beach, Oban.

Occurs in five of the gatherings—in all rare, and all off the shores of the Cumbraes; in 3 to 15 fathoms, mostly on somewhat hard bottom.

CYTHERE LUTEA, Müller.

Cythere reniformis, Baird.	Brit. Entom., p. 169.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 395.

DISTRIBUTION—*Recent:* Baffin's Bay, Iceland, Gulf of St. Lawrence, North Sea, Great Britain, Ireland, Baltic, Mediterranean. *Fossil:* Occurring in nearly all the beds on the west of Scotland, but less frequent on the east. Ireland, Belfast New Docks (silt), and in the raised beach, Portrush; Canada and Norway, post-tertiary.

A widely distributed species in the Clyde district, occurring in thirty-one of the gatherings—in ten rare, in eighteen moderately common, and only in three prevailing to any extent.

CYTHERE VIRIDIS, Müller.

Cythere viridis, Müller.	Entom., p. 64.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 397.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland, Holland. *Fossil:* In nearly all the clay beds on the west of Scotland, less so on the east of Scotland. Ireland—Portrush raised beach; Norway, post-tertiary beds.

This is one of the commonest species in the Firth of Clyde, and although considered a littoral species, is found in every one of the forty gatherings—in fourteen rare, in twenty-four moderately common, and in two very common. Ranging from low-water to 30 fathoms.

I may remark that in all my gatherings I have never found one of this species green or even greenish, as the specific name implies.

CYTHERE PELLUCIDA, Baird.

Cythere pellucida, Baird.	Brit. Entom., p. 173.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 397.
„ „ Brady & Robertson.	Ann. & Mag. Nat. Hist., ser. 4., vol. iii.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland, Holland, Mediterranean, Gulf of St. Lawrence. *Fossil:* Common in the clay deposits of England, Scotland, Ireland, and Norway—both associated with Arctic shells, and in the silts and raised beaches.

Occurs in thirty-three of the gatherings of the Firth of Clyde—in seven rare, in fourteen moderately common, and in twelve very common. More frequently in greater abundance than any other species of Ostracoda in Clyde district.

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CYTHERE CASTANEA, G. O. Sars.

Cythere castanea, G. O. Sars. Overs. Nory. Mar. Ostrac., p. 32.
,, ,, Brady. Monog. Rec. Brit. Ostrac., p. 398.
,, ,, Brady & Robertson. Ann. Mag. Nat. Hist., ser. 4, vol. iii.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway, Holland. *Fossil:* Occurring in most of the clay deposits on the west of Scotland and South Wales, Cardiff New Dock-basin.

A common brackish water or estuarine species, also common under purely marine conditions.

It occurs in fifteen of the gatherings—in ten rare, and in five moderately common; in from 1 to 25 fathoms.

CYTHERE PORCELLANEA, Brady.

Cythere porcellanea, Brady. Ann. Mag. Nat. Hist., ser. 4, vol. iii.,
,, ,, Brady & Robertson. Ibid.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Holland. *Fossil:* West Tarbert, Cartsdyke, Cumbrae, Kilchattan, Dalmuir; South Wales, Cardiff New Dock-basin.

Occurs in eight of the forty gatherings from Clyde district—in four rare and in four moderately common; in 1 to 25 fathoms.

CYTHERE MACALLANA, Brady & Robertson.

Cythere Macallana, Brady & Robertson. Ann. & Mag. Nat. Hist., ser. 4, vol. iii.
,, *propinqua*, G. O. Sars. Undersö. over Christianiafj., p. 57.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Holland. *Fossil:* Scotland—Kilchattan, Cumbrae, Cartsdyke, Dalmuir, West Tarbert; South Wales, Cardiff New Dock-basin.

Rather rare in the Firth of Clyde, occurring only in five of the gatherings—in two rare, in two moderately common, and in one common.

CYTHERE TENERA, Brady.

Cythere tenera, Brady. Monog. Rec. Brit. Ostrac., p. 399.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Bay of Biscay. *Fossil:* Scotland—Wick, Dipple, Oban raised beach; Ireland—Portrush; South Wales—Cardiff New Dock-basin; England—Mersey.

Occurs in twenty-seven of the Clyde gatherings—in six rare, in fourteen moderately common, and in seven very common; ranging from 6 to 30 fathoms. Prevailing most on muddy bottoms, where it is generally associated with *Cythere porcellanea*, and in some cases it is difficult to distinguish the one from the other.

CYTHERE CRISPATA, Brady.

Cythere crispata, Brady. Monog. Rec. Brit. Ostrac., p. 399.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway, Australia, Hong Kong. *Fossil:* Scotland—Paisley; Ireland, Portrush raised beach; Norway.

In the Firth of Clyde it occurs in seventeen of the gatherings—in nine rare, and in eight moderately common; from 4 to 25 fathoms, and most prevalent on sandy mud bottoms.

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CYTHERE BADIA, Norman.

Cythere badia, Norman.	Ann. & Mag. Nat. Hist. for Jan., 1862.
,, *cicatricosa*, G. O. Sars.	Overs. Nory. Mar. p. 33.
,, *badia*, Brady.	Monog. Rec. Brit. Ostrac., p. 399.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway, Mediterranean, Australia.

This species is rather sparsely distributed over the Firth of Clyde, having been obtained in only four of the forty gatherings—in three rare, and in one common; ranging from low water to 20 fathoms.

CYTHERE RUBIDA, Brady.

Cythere rubida, Brady.	Monog. Rec. Brit. Ostrac., p. 400.

This species was hitherto only met with at Clachland Point, Arran, in rock pools (Norman), and now at low water on sand covered stones, Kames Bay, Cumbrae.

CYTHERE ALBO-MACULATA, Baird.

Cythere albo-maculata, Baird.	Brit. Entom. 169.
,, ,, Brady.	Monog. Rec. Brit. Ostrac., p. 402.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Bay of Biscay, Levant, Cape Verde, Norway. *Fossil:* Post-tertiary clays and raised beaches, Scotland, Ireland, and Norway.

This is rather a littoral species, and does not appear so often in the dredgings as other species less common in the district. It occurs in seventeen of the gatherings—in six rare, in ten moderately rare, and in one common; ranging from low water to 30 fathoms.

As the name implies, this species is often found maculated with small dashes of black within the tidal belt, but in deeper water they are mostly, if not always, of a uniform colour, from a yellowish-brown to a dirty white. That these maculations are the results of food or peculiar localities, rather than constant specific characters, may be inferred from the fact that at some places almost all the species of Ostracoda are affected in the same way. At Whitby, near St. Mary's Island, a few miles north of Newcastle, this was the case with nearly all the Ostracoda in a gathering of sandy mud scraped off the rocks near low water. *Cythere lutea*, and all the members present of the genus *Paradoxostoma*, as well as *Cythere albo-maculata* and *Cytherura nigrescens* shewed a similar state of maculation.

CYTHERE CONVEXA, Baird.

Cythere convexa, Baird.	Brit. Entom., p. 174.
,, *punctata*, Jones.	Entom. Ter. Eng., p. 24.
,, *convexa*, Brady.	Monog. Rec. Brit. Ostrac., p. 401.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Levant. *Fossil:* Scotland—Errol, Paisley, Cumbrae, Lochgilp, and raised beaches, Cumbrae, Oban, West Tarbert silt. Ireland—raised beach, Portrush, silt, Belfast New Docks.

This species is taken moderately common by the dredge in the Clyde district, but not abundantly in any of the gatherings. It is most frequently met with in the muddy sand and harder ground, but seldom on the purely mud bottom of the lochs in the Firth of Clyde.

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CYTHERE CUNEIFORMIS, Brady.

Cythere ventricosa, Sars.	*Loc.cit.*, p. 34.
„ *cuneiformis*, Brady.	Monog. Rec. Brit. Ostrac., p. 404.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway. *Fossil:* Raised beach, Oban, West Tarbert, and Bridge of Allan silt.

This species is seldom taken in any great abundance. It occurs in twelve gatherings in the Firth of Clyde—in nine rare, and in three moderately common; ranging from low water to 30 fathoms.

CYTHERE LIMICOLA, Norman.

Cythere limicola, Norman.	Nat. Hist. Trans. Northumb. and Durh., vol. i. p. 20.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 405.

DISTRIBUTION—*Recent:* Great Britain, Norway, Baffin's Bay. *Fossil:* Scotland—Tangyburn, Campbeltown; Stobcross, Glasgow; Dumbarton, Inch Lonaig, Lochlomond; Cartsdyke, Greenock; Cumbrae, Kilchattan, Bute; Kyles of Bute, Duntroon, Argyleshire; Terally, Wigtownshire; Gamrie, Banffshire; Canada—Post-tertiary beds.

Although this is rare as a recent species, it is common in the post-tertiary deposits, but absent in the raised beaches and silts. It only occurs in one of the forty gatherings in the Clyde district (off Girvan, in 12 to 15 fathoms; bottom, dead shells and small gravel), and in that one rare.

CYTHERE TUBERCULATA, G. O. Sars.

Cythereis tuberculata, G. O. Sars.	*Loc. cit.*, p. 37.
Cythere „ Brady.	Monog. Rec. Brit. Ostrac., p. 406.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway, Spitzbergen, Baffin's Bay, Bay of Biscay, Gulf of St. Lawrence, West Indies. *Fossil:* In nearly all the post-tertiary beds of Scotland; England—Bridlington, Hopton Cliff; Branston Fen; South Wales—Cardiff New Dock-basin; Ireland—Belfast New Docks, Woodburn, near Carrickfergus.

Occurs in thirty of the gatherings in the Clyde district—in eight rare, in seventeen moderately common, and in five very common.

CYTHERE CONCINNA, Jones.

Cythere concinna, Jones.	Ter. Entom., p. 29.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 408.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway, Gulf of St. Lawrence, Spitzbergen, Davis' Straits. *Fossil:* Crag, England; post-tertiary clays and raised beaches, Scotland, Ireland, Norway.

This is considered a Scandinavian type. Recent it is moderately common in the Clyde district; where it does occur it is often in considerable numbers, but generally less or more confined to particular areas. It is common in most of the post-tertiary beds in the west of Scotland.

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CYTHERE ANGULATA, G. O. Sars.

Cythere angulata, G. O. Sars. Overs. Nory. Mar. Ostrac., p. 40.
" " Brady. Monog. Rec. Brit. Ostrac., p. 409.

DISTRIBUTION—*Recent:* Great Britain, Norway, Baffin's Bay, Davis' Straits. *Fossil:* post-tertiary, England, Scotland, Ireland, and Norway.

Occurs in twenty-eight of the forty gatherings of the Clyde district—in most of these moderately common, but seldom in great profusion. It is equally abundant in the post-tertiary beds in the west of Scotland. Those of the clays are generally more strongly marked than recent species.

CYTHERE EMARGINATA, G. O. Sars.

Cythere emarginata, G. O. Sars. Overs. Nory. Mar. Ostrac., p. 38.
" " Brady. Monog. Rec. Brit. Ostrac., p. 475.

DISTRIBUTION—*Recent:* Arctic Seas, Norway, Gulf of St. Lawrence, Scotland. *Fossil:* Scotland, England, Ireland, Norway, and Canada.

A rare recent species in this country, only occurring once in the forty gatherings from the Clyde district,—viz., in Lochfyne, off Inveraray, in 25 fathoms, mud bottom, where it was moderately common. It occurred also in a gathering from Lerwick Bay, Shetland, in 10 to 12 fathoms, gravelly, sandy, mud bottom.

It is moderately common in the post-tertiary clays in the east of Scotland.

CYTHERE FINMARCHICA, G. O. Sars.

Cythereis finmarchica, Sars. *Loc. cit.* p. 41.
Cythere " Brady. Monog. Rec. Brit. Ostrac., p. 410.

DISTRIBUTION—*Recent:* Davis' Straits, Norway, Great Britain, Ireland, Bay of Biscay, Cape Verde.

This species has only occurred once in my gatherings in the Firth of Clyde. This was in Lochfyne, off Inveraray; but it is occasionally met with both off the English and Irish coasts.

CYTHERE PULCHELLA, Brady.

Cythere pulchella, Brady. Monog. Rec. Brit. Ostrac., p. 404.
" " Brady & Robertson. Ann. Mag. Nat. Hist., ser. iv., vol. iii., p. 369.

DISTRIBUTION—*Recent:* Scotland, Ireland, Baffin's Bay, Holland. *Fossil:* Scotland—common in the post-tertiary clays, silts, and raised beaches; Ireland—Woodburn raised beach, Portrush; silt, Belfast New Dock.

This species is moderately common in the Firth of Clyde, but never in any great abundance. It is apt to be mistaken for the young of *Cythere villosa*. It occurs in fifteen of the dredgings or gatherings in the Clyde district—in ten rare, and in five moderately common; ranging from low water to 20 fathoms. In the fossil, as in the recent state, it never occurs in great abundance.

CYTHERE ROBERTSONI, Brady.

Cythere Robertsoni, Brady. Ann. Mag. Nat. Hist., ser. iv., vol. ii., p. 33.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway. *Fossil:* Lochgilp, Scotland; Norway.

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It occurs in seventeen of the Firth of Clyde gatherings—in seven it is rare, in nine moderately common, and in one common; ranging from 5 to 22 fathoms.

CYTHERE VILLOSA, G. O. Sars.

Cythereis villosa, G. O. Sars.	*Loc. cit.*, p. 42.
Cythere ,, Brady.	Monog. Rec. Brit. Ostrac., p. 411.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway, Bay of Biscay, Davis' Straits, Gulf of St. Lawrence. *Fossil:* Scotland, England, Ireland, Norway.

From the annexed table, this is seen to be a very common species in the Firth of Clyde, prevailing mostly in 6 to 10 fathoms, on sandy gravelly bottoms. It is generally absent in the deeper muddy lochs. It is also a common post-tertiary species, but seldom in any great abundance.

CYTHERE LATICARINA, Brady.

Cythere laticarina, Brady.	Monog. Rec. Brit. Ostrac., p. 412.

DISTRIBUTION—*Recent:* Great Britain, Spitzbergen. *Fossil:* Scotland, Raised beach, Oban.

Very rare in the Clyde district, occurring only in one of the gatherings—Fintry Bay, Cumbrae.

CYTHERE QUADRIDENTATA, Baird.

Cythere quadridentata, Baird.	Brit. Entom., p. 173.
,, ,, Brady.	Monog. Rec. Brit. Ostrac., p. 413.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Bay of Biscay. *Fossil:* Scotland—Lochgilp.

Occurs in ten of the Clyde gatherings—in four rare, and in four moderately common; 6 to 30 fathoms.

CYTHERE EMACIATA, Brady.

Cythere emaciata, Brady.	Brit. Assoc. Report, 1866, p. 210.
,, ,, ,,	Monog. Rec. Brit. Ostrac., p. 414.

DISTRIBUTION—*Recent:* Great Britain, Ireland. *Fossil:* Scotland—raised beaches, Irvine and Lochgilp.

Met with sparingly in the Firth of Clyde. Occurring in eight out of the forty gatherings—in four common, and in four moderately common; from 7 to 30 fathoms.

CYTHERE DUNELMENSIS, Norman.

Cythereis Dunelmensis, Norman.	Nat. Hist. Northumb. and Durh., vol. i., p. 22.
,, *horrida*, G. O. Sars.	Overs. Nory. Mar. Ostrac., p. 45.
Cythere Dunelmensis, Brady.	Monog. Rec. Brit. Ostrac., p. 416.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Arctic Seas, Gulf of St. Lawrence. *Fossil:* Scotland—nearly in all the post-tertiary beds; England—Bridlington; Ireland—Woodburn and Belfast New Docks.

In the Firth of Clyde this species occurs in ten out of the forty gatherings—in two rare, in five moderately common, and in three very common; in

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depths from 8 to 30 fathoms, and prevails most in the deeper water on muddy bottoms.

CYTHERE WHITEII, Baird.

Cythere Whiteii, Baird.	Brit. Entom., p. 175.
,, ,, Brady.	Monog. Rec. Brit. Ostrac., p. 416.

DISTRIBUTION—*Recent:* Great Britain, Levant, Gulf of St. Lawrence.

This is a rare species, and was only noticed in the gatherings from Kilchattan Bay and Campbeltown Loch. Where it does occur the examples are always few. It has only been recorded fossil from Belfast New Docks.

CYTHERE ANTIQUATA, Baird.

Cythereis antiquata, Baird.	Brit. Entom., p. 176.
Cythere ,, Brady.	Monog. Rec. Brit. Ostrac., p. 417.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Bay of Biscay, Levant. *Fossil:* Scotland—Oban raised beach; England—upper boulder clay, Chester; Ireland—Belfast New Docks.

A moderately common species in the Firth of Clyde, occurring in twenty-two gatherings out of the forty; not abundant in any, and rare in eight.

CYTHERE JONESII, Baird.

Cythereis Jonesii, Baird.	Brit. Entom., p. 175.
Cythere ,, Brady.	Monog. Rec. Brit. Ostrac., p. 418.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Bay of Biscay, Levant. *Fossil:* England—Newton, near Chester; Ireland—Belfast New Docks; Belgium and France, Eocene.

Occurs in twenty-four of the Firth of Clyde gatherings—in seven rare, in sixteen moderately common, and in one very common; from 6 to 30 fathoms; prevailing most on mud or sandy mud bottoms.

CYTHERE GIBBOSA, Brady & Robertson.

Cythere gibbosa, Brady & Robertson.	Ann. & Mag. Nat. Hist., ser. iv., vol. iii., p. 368.

DISTRIBUTION—*Recent:* Great Britain, Ireland. *Fossil:* Raised beach, Portrush, Ireland.

Occurs only in two of the forty gatherings from the Firth of Clyde—in one rare (east Tarbert Loch), common off Greenock pier, in 4 to 6 fathoms, where, it will be observed, the water must be more or less brackish, which agrees with its other habitats—viz., Montrose Basin, Scotland; Tidal Pond, Westport, Ireland; Budle Bay and Seaton Burn, below the sluice, England—all of which are more or less brackish.

CYTHERIDEA PAPILLOSA, Bosquet.

Cytheridea papillosa, Bosquet.	Entom. Foss. Ter. Tertiair, France, p. 42.
,, ,, Brady.	Monog. Rec. Brit. Ostrac., p. 423.

DISTRIBUTION—*Recent:* Baffin's Bay, Gulf of St. Lawrence, Norway, Great Britain. *Fossil:* England, Scotland, Canada, France, tertiary.

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This species seems to have a strong preference in the Firth of Clyde to a soft muddy bottom. In most of the lochs it prevails greatly. Out of the forty gatherings it occurred in thirty. It is generally associated with *Cytheridea punctillata*, but seldom in equal numbers at the same place. *C. punctillata* seems to prefer ground somewhat harder, and generally prevails there over *C. papillosa*.

CYTHERIDEA PUNCTILLATA, Brady.

Cytheridea punctillata, Brady.	Monog. Rec. Brit. Ostrac., p. 424.
,, *proxima*, G. O. Sars.	Overs. Nory. Mar. Ostrac., p. 54.

DISTRIBUTION—*Recent:* Baffin's Bay, Gulf of St. Lawrence, Norway, Britain. *Fossil:* Scotland, Ireland, Norway.

This is also a common species in the firth, but less so than *C. papillosa*. It is generally most common on sandy muddy ground in deepish water, but is also met with sparingly in depths from 5 to 8 fathoms. It prevails generally in the post-tertiary clays both on the east and west of Scotland. *C. papillosa* is less frequent and fewer in numbers in the clays.

CYTHERIDEA ELONGATA, Brady.

Cythere angustata, Baird.	(Not Munster). Brit. Entom., p. 172.
,, *elongata*, Brady.	Monog. Rec. Brit. Ostrac., p. 421.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Bay of Biscay, Gulf of St. Lawrence.

This species may be considered moderately rare in the Firth of Clyde; it occurs in ten gatherings out of the forty—in six rare, in four moderately common. Its character as a fossil is restricted in Scotland and Ireland to the estuarine silts and raised beaches; and in England to a deposit (Hopton Cliff, near Yarmouth) described as Middle Glacial by Messrs. S. V. Wood, jun., and F. W. Harmer, in the Palæontographical Society's volume for 1871, p. 22.

CYTHERIDEA SUBFLAVESCENS, Brady.

Cythere subflavescens, Brady.	Brit. Assoc. Report, 1866, p. 210.,
Cytheridea ,, Brady.	Monog. Rec. Brit. Ostrac., p. 429.

DISTRIBUTION—*Recent:* Scotland.

This is a very rare species, hitherto only known from one specimen dredged by the Rev. A. M. Norman in sand amongst the Hebrides, in 45 to 60 fathoms, in the year 1866. It occurs twice in the firth gatherings; one example in Rothesay Bay in 15 to 18 fathoms, and three examples off Fintry Bay in 22 fathoms.

CYTHERIDEA TOROSA, Brady.

Cyprideis torosa, Jones.	Ter. Entom. of Eng., 1851, p. 21.
Cytheridea ,, Brady.	Monog. Rec. Brit. Ostrac., p. 425.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway, Levant, Azoff. *Fossil:* England and Scotland.

This being a decidedly brackish water species, is only found in two of the firth gatherings—off Langbank and Greenock, at both places brackish.

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EUCYTHERE DECLIVIS, Norman.

Cythere declivis, Norman.	Nat. Hist., Trans., Northumb. & Dur., vol. i., p. 16.
Eucythere ,, Brady.	Monog. Rec. Brit. Ostrac., p. 430.

DISTRIBUTION—*Recent:* Norway, Great Britain, and Ireland.

This species is rare in the Firth of Clyde, occurring only in five gatherings out of the forty—in two only moderately common—Kilchattan Bay in 20 to 25 fathoms, and Roseneath Bay in 15 fathoms, both in sandy mud. It has only been found fossil in the College post-tertiary deposit, Cumbrae.

EUCYTHERE ARGUS, G. O. Sars.

Cytheropsis argus, Sars.	Overs. Nory. Mar. Ostrac., p. 58.
Eucythere ,, Brady.	Monog. Rec. Brit. Ostrac., p. 431.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland, Gulf of St. Lawrence. *Fossil:* Scotland, England, Ireland, Norway, and Canada.

Moderately common in the Firth of Clyde; found in twenty-two out of the forty gatherings, in none very abundant. It seems not to be fastidious, either in the character of bottom, or the depth or purity of the water. It was found in Loch Striven in mud in 26 fathoms; off Whiting Bay, in 7 fathoms muddy sand; off Greenock, in 4 to 6 fathoms muddy sand, in water less or more brackish; also between Port-Glasgow and Langbank, where the water is still more brackish and impure.

KRITHE BARTONENSIS, Jones.

Cytherideis Bartonensis, Jones.		
Ilyobates ,,	Brady.	Monog. Tert. Entom., p. 50.
Krithe ,,	B., C., & R.	Monog. Post-tertiary Entom., vol. xxviii., p. 184.

DISTRIBUTION—*Recent:* Norway, Great Britain. *Fossil:* England, Scotland, Norway.

This species is not uncommon in the Firth of Clyde, occurring in seventeen out of the forty gatherings, from 8 to 30 fathoms, chiefly on sandy mud bottoms. In some of the dredgings it was very abundant, and in all stages of growth. This is more remarkable from the infrequency with which the young of Ostracoda are met with; often where the adults are in great profusion scarcely an immature form will be seen, and seldom even what could be called fry.

LOXOCONCHA IMPRESSA, Baird.

Cythere impressa, Baird.	Brit. Entom., p. 173.
Loxoconcha ,, Brady.	Monog. Rec. Brit. Ostrac., p. 433.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland, Bay of Biscay. *Fossil:* Scotland, Ireland, Norway.

This is a very common species, and occurs in almost all the gatherings in the Firth of Clyde. It is less common in the fossil state, and chiefly confined to the silts and raised beaches.

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LOXOCONCHA GRANULATA, Sars.

Loxoconcha granulata, Sars.	*Loc. cit.*, p. 64.
Loxoconcha ,, Brady.	Monog. Rec. Brit. Ostrac., p. 434.

DISTRIBUTION—*Recent:* Britain, Norway.

It is not common in the Firth of Clyde, occurring sparingly in thirteen of the gatherings, but in a few—Roseneath, Lochgoil, and Gareloch—it is abundant. Unknown in the fossil state.

LOXOCONCHA TAMARINDUS, Jones.

Cytheredeis tamarindus, Jones.	Ter. Entom., p. 49.
Loxoconcha ,, Brady.	Monog. Rec. Brit. Ostrac., p. 435.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland, Bay of Biscay. *Fossil:* Crag, England; glacial and raised beaches, England, Scotland, Ireland, Norway.

A common species, and occurring in thirty-two of the forty gatherings. Fossil in nearly all the post-tertiary clays in the west of Scotland, less so in the east.

LOXOCONCHA GUTTATA, Norman.

Cythere guttata, Norman.	Nat. Hist. Trans. Northumb. and Durh., vol. i., p. 19.
Loxoconcha ,, Brady.	Monog. Rec. Brit. Ostrac., p. 436.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Bay of Biscay, Levant. *Fossil:* Scotland.

Found in eighteen of the gatherings in the Firth of Clyde—in two rare, in fifteen moderately common, in one very common (Campbeltown Loch). It occurs in from 8 to 30 fathoms, and mostly in sandy mud.

I have it in a gathering from 8 to 100 fathoms, St. Magnus Bay, Shetland (Jeffreys), but not one *L. impressa;* and common in a gathering at very low water Isle of Man, associated with *L. impressa.* Its fossil habitats are confined to silt deposits, Drip Bridge and Bridge of Allan, Stirlingshire.

LOXOCONCHA MULTIFORA, Norman.

Cythere multifora, Norman.	Brit. Assoc. Report, p. 192.
Cytheropteron multiforum, Brady.	Monog. Rec. Brit. Ostrac., p. 449.
Loxoconcha multifora, B., C., & R.	Monog. Post-tertiary Ostrac. Palæontological Soc., p. 187.

DISTRIBUTION—*Recent:* Great Britain, Ireland.

This species is also moderately common in the Firth of Clyde, where it does not seem to shew much preference either to the depth of water or character of bottom. Fossil in raised beach, Portrush, Ireland.

LOXOCONCHA PUSILLA, Brady & Robertson.

Loxoconcha pusilla, B. & R.	Ann. and Mag. Nat. Hist., July 1870, p. 23.

DISTRIBUTION—*Recent:* Holland, Netherlands, England, Scotland.

It is chiefly confined to tidal rivers and brackish fens. In the Firth of Clyde it was found only in two localities—off Greenock pier, where it has the

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mixture of fresh water of the River Clyde, and at Kames Bay, Cumbrae, at low water, where a small stream of fresh water spreads over the shore, bathing the place alternately with stream and tide.

LOXOCONCHA FRAGILIS, G. O. Sars.

Loxoconcha fragilis, G. O. Sars.	Overs. Nory. Mar. Ostrac., p. 65.
„ „ Brady & Robertson.	Ann. and Mag. Nat. Hist., July, 1870, p. 24.

DISTRIBUTION—*Recent:* Norway, England, Scotland.

The habitats of this species—River Clyde, Montrose Basin, Budle Bay—shew its brackish character. In the Firth of Clyde it occurred off Greenock, in 4 to 6 fathoms, and between Port-Glasgow and Langbank a few feet beyond low water.

Occurs fossil in the post-tertiary clays at Cartsdyke, Greenock, and Paisley, associated with marine Arctic shells.

XESTOLEBERIS AURANTIA, Baird.

Cythere aurantia, Baird.	Mag. Zool. and Bot., vol. ii., p. 143.
Xestoleberis nitida, G. O. Sars.	Overs. Nory. Mar. Ostrac., p. 67.
„ *aurantia*, Brady.	Monog. Rec. Brit. Ostrac., 437.

DISTRIBUTION—*Recent:* Holland, Great Britain, Ireland. *Fossil:* Scotland, England, Ireland, Norway.

This being purely a littoral species, is only found in one of the firth gatherings, at low water, Cumbrae; all the others being taken in deeper water with the dredge. It has been met with fossil only in silts and raised beaches—raised beach, Cumbrae, Scotland; silts, New Dock-basin, Cardiff, South Wales; New Docks at Belfast, Ireland.

XESTOLEBERIS DEPRESSA, G. O. Sars.

Xestoleberis depressa, G. O. Sars.	Overs. Nory. Mar. Ostrac., p. 68.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 438.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway, Spitzbergen, Gulf of St. Lawrence. *Fossil:* Scotland—West Tarbert, Lochgilp, Paisley, raised beach, Oban; Ireland—New Docks, Belfast; Norway; Canada.

This species is moderately common in the Firth of Clyde, occurring in twenty-three of forty gatherings, but in none in any great profusion, and is found on both hard and soft ground.

CYTHERURA NIGRESCENS, Baird.

Cythere nigrescens, Baird.	Mag. Zool. and Bot., vol. ii., p. 143.
Cytherura „ G. O. Sars.	Overs. Nory. Mar. Ostrac., p. 71.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 440.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland. *Fossil:* England—Hopton Cliff; Scotland—nearly all the post-tertiary clays on the west and at Drip Bridge; Ireland—New Docks, Belfast, and at Portrush; Norway; Canada.

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This is a common littoral species, yet not uncommon in deeper water. It occurs in twenty-nine gatherings out of the forty in Firth of Clyde, at depths from 7 to 30 fathoms; prevailing most from 4 to 9 fathoms; yet moderately common in various depths from 10 to 30 fathoms, both on soft and harder bottoms.

CYTHERURA ANGULATA, Brady.

Cytherura angulata, Brady. Monog. Rec. Brit. Ostrac., p. 440.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Norway. *Fossil:* Scotland—raised beach, Oban; South Wales—Cardiff New Dock-basin; Ireland—Belfast New Docks, Portrush; Norway.

Occurs in eighteen of the gatherings in the firth—in eleven rare, and in seven moderately common, but in none in profusion.

CYTHERURA STRIATA, G. O. Sars.

Cytherura striata, G. O. Sars. Overs. Nory. Mar., p. 74.
" " Brady. Monog. Rec. Brit. Ostrac., p. 441.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland. *Fossil:* Scotland—Lochgilp, West Tarbert, Kyles of Bute, Cumbrae, Cartsdyke; South Wales—New Dock-basin, Cardiff; Ireland—New Docks at Belfast; Norway; Canada.

Moderately common in the Firth of Clyde. In twenty gatherings, eleven were rare, eight common or moderately common, and one very common.

CYTHERURA LINEATA, Brady.

Cytherura lineata, Brady. Monog. Rec. Brit. Ostrac., p. 441.

This species has hitherto been obtained only in dredgings from the north of Scotland, the Minch, 50 to 60 fathoms (Jeffreys), Isle of Skye (Rev. Mr. Barlee). In the Firth of Clyde it occurs in two gatherings; west of the Ferry-house in 6 fathoms, and off Inverkip in 12 fathoms. It has not been met with fossil, as far as known.

CYTHERURA CUNEATA, Brady.

Cytherura cuneata, Brady. Monog. Rec. Brit. Ostrac., p. 442.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Levant. *Fossil:* Scotland—West Tarbert, with Arctic shells.

In the Clyde district this species may be considered rather rare, although it occurs in fifteen gatherings out of the forty. It is rare in eight, and only prevails in one, off Ardrishaig, in 6 fathoms, bottom muddy sand.

CYTHERURA SARSII, Brady.

Cytherura Sarsii, Brady. Monog. Rec. Brit. Ostrac., p. 442.

DISTRIBUTION—*Recent:* Scotland. *Fossil:* Scotland—Duntroon, Lochgilp, Kyles of Bute, Cartsdyke, Paisley. In all associated with Arctic shells.

Occurs in nine of the firth gatherings, rare in five, and moderately common in four.

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CYTHERURA SIMILIS, Sars.

Cytherura similis, Sars.	*Loc. cit.*, p. 72.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 442.

DISTRIBUTION—*Recent:* Norway, Great Britain, Holland, Spitzbergen. *Fossil:* Duntroon, Lochgilp, Kyles of Bute, Kilchattan, Cumbrae, Dumbarton, Cartsdyke, Dalmuir, Barrie; Ireland—New Docks at Belfast, Portrush; Norway.

Rare in the Clyde district; occurs only in four out of forty of the firth dredgings—in three rare, in one moderately common.

CYTHERURA UNDATA, Sars.

Cytherura undata, G. O. Sars.	Overs. Nory. Mar. Ostrac., p. 75.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 443.

DISTRIBUTION—*Recent:* Baffin's Bay, Gulf of St. Lawrence, Spitzbergen, Norway, Great Britain, Ireland. *Fossil:* Scotland, nearly all the post-tertiary beds; Ireland—New Docks at Belfast, Portrush.

Very common in the Firth of Clyde, occurring in thirty gatherings—in ten rare or rather rare, in fourteen common or moderately common, and in six very prevalent.

CYTHERURA PRODUCTA, Brady.

Cytherura producta, Brady.	Monog. Rec. Brit. Ostrac., p. 443.

DISTRIBUTION—*Recent:* Great Britain, Ireland. *Fossil:* South Wales—Cardiff New Dock-basin.

Rare in the Firth of Clyde, occurring only in six of forty gatherings—in three rare, and in three moderately common. In one of the gatherings (De'il's Dyke) it was found in greater numbers than any other in the firth, yet in another gathering close by, in about the same depth of water, and to all appearance the same character of bottom, not one was found. It has been obtained in the west of Scotland, in the Minch (Rev. A. M. Norman), and what is noteworthy, it has been found in the tidal rivers, Aln, Thames, England; and the River Scheldt, Netherlands,* all more or less brackish.

CYTHERURA ROBERTSONI, Brady.

Cytherura Robertsoni, Brady.	Monog. Rec. Brit. Ostrac., p. 444.

DISTRIBUTION—*Recent:* Great Britain, Ireland. *Fossil:* Scotland—West Tarbert silt; Canada—Saxicava sand.

This is characteristically a brackish water species, occurring only at the few places in the firth favourable to its habits; these are off Greenock, and between Port-Glasgow and Langbank, and near the head of Loch Ryan.

CYTHERURA GIBBA, Müller.

Cythere gibba, Müller.	Entom., p. 24.
Cytherura „ Sars.	Overs. Nory. Mar. Ostrac., p. 70.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 444.

DISTRIBUTION—*Recent:* Britain, Baltic Sea, North Sea. *Fossil:* Scotland

* Ann. Mag. Nat. Hist. for July, 1870.

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—West Tarbert, raised beach at Oban; Ireland—Belfast New Docks, Portrush; River Scheldt.

This species is moderately common in the Firth of Clyde, occurring in fourteen gatherings—in ten rare, in three common or moderately common, and in one (St. Ninian's Bay) abundant.

CYTHERURA CORNUTA, Brady.

Cytherura cornuta, Brady. Monog. Rec. Brit. Ostrac., p. 445.

DISTRIBUTION—*Recent:* Britain, Ireland, Dardanelles, Levant. *Fossil:* Scotland, West Tarbert silt; Norway.

A rather rare species in the Firth of Clyde, occurring only in nine gatherings—in six rare, and in three moderately common.

CYTHERURA ACUTICOSTATA, G. O. Sars.

Cytherura acuticostata, G. O. Sars. Overs. Nory. Mar. Ostrac., p. 76.
,, ,, Brady. Monog. Rec. Brit. Ostrac., p. 445.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Holland. *Fossil:* Scotland—Raised beach at Oban; Belfast New Docks, Norway.

Moderately common, occurring in seventeen of the firth gatherings—in eight rare, and in nine common or moderately common, in none abundant.

CYTHERURA CLATHRATA, G. O. Sars.

Cytherura clathrata, Brady. Monog. Rec. Brit. Ostrac., p. 446.

DISTRIBUTION—*Recent:* Baffin's Bay, Norway, Great Britain, Ireland. *Fossil:* Nearly in all the post-tertiary clay deposits on the west of Scotland, and Drip Bridge in the east; Ireland, Portrush; England, Bridlington; Norway.

Very rare in the Clyde district, occurring only in one of the forty gatherings (Callum's Bay, south end of Bute), and there only one instance.

CYTHERURA CELLULOSA, Norman.

Cythere cellulosa, Norman. Nat. Hist. Trans. Northumb. and Durh., vol. i., p. 22.
Cytherura nana, Sars. Overs. Nory. Mar. Ostrac., p. 446.
,, *cellulosa*, Brady. Monog. Rec. Brit. Ostrac., p. 446.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland, Holland. *Fossil:* Scotland—Raised beach at Oban; Ireland, Belfast New Docks; Norway.

Common in the Clyde district, occurring in twenty-seven of the gatherings—in fifteen rare, in eleven moderately common, and in one only abundant.

CYTHERURA FLAVESCENS, Brady.

Cytherura flavescens, Brady. Ann. & Mag. Nat. Hist., ser. 4., vol. iii., p. 49.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Holland. *Fossil:* Scotland—Kyles of Bute.

Occurs in fourteen of the gatherings—in seven rare, and in seven common.

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CYTHEROPTERON LATISSIMUM, Norman.

Cythere latissima, Norman.	Nat. Hist. Trans. Northumb. and Durh., vol. i., p. 19.
Cytheropteron convexum, G. O. Sars.	Overs. Nory. Mar. Ostrac., p. 80.
„ *latissimum*, Brady.	Monog. Rec. Brit. Ostrac., p. 448.

DISTRIBUTION—*Recent:* Baffin's Bay, Norway, Great Britain, Ireland, Spitzbergen. *Fossil:* Scotland—nearly in all the post-tertiary beds; England, Bridlington; Norway and Canada.

Common in the Clyde district, occurring in twenty-five gatherings—rare in five, common or moderately common in fourteen, abundant in six. Although this species is very common in some gatherings, yet like others, none may be found at a very short distance, even when the conditions are apparently similar.

CYTHEROPTERON NODOSUM, Brady.

Cytheropteron nodosum, Brady.	Monog. Rec. Brit. Ostrac., p. 448.

DISTRIBUTION—*Recent:* Britain, Ireland, Gulf of St. Lawrence. *Fossil:* Scotland—nearly in all the post-tertiary beds; England, Bridlington; Ireland, Woodburn, Portrush.

Much less common than the preceding species. It occurs in fourteen of the gatherings—in nine it is rare, in four moderately common, and prevails only in one.

CYTHEROPTERON PUNCTATUM, Brady.

Cytheropteron punctatum, Brady.	Monog. Rec. Brit. Ostrac., p. 449.

DISTRIBUTION—*Recent:* Britain, Ireland.

This species may be said to be locally common in the Clyde district, although it was found only in six forty of the gatherings, in one of these, Lochgoil, in 30 fathoms sandy mud, it was very common, and moderately common off Girvan in 12 to 15 fathoms, on a bank chiefly gravel and dead shells.

CYTHEROPTERON ALATUM, G. O. Sars.

Cytheropteron alatum, Norman.	Brit. Assoc. Report.
Cytheropteron ornatum, Brady & Robertson.	Ann. & Mag. Nat. Hist. January, 1872.

DISTRIBUTION—*Recent:* Scotland; Norway.

The young of *C. alatum* was mistaken for a new species, and named *C. ornatum*. This chiefly arose from the presence of a semitransparent curve on the lateral angles of the alæ; but on further investigation, with a better supply, the changes from *C. ornatum* could be traced into the adult form of *C. alatum*.

It was obtained in nine of the firth gatherings—in two it was rare, and in seven common or moderately common. In the Clyde district it has been obtained in from 15 to 26 fathoms on ground more or less soft, and in Shetland, by Rev. A. M. Norman, in deep water, and by Sars, in Norway, in 250 fathoms.

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CYTHEROPTERON ANGULATUM, Brady & Robertson.

Cytheropteron angulatum, B. & R. Ann. & Mag. Nat. Hist., ser. 4, vol. vi., p. 62.

DISTRIBUTION—*Recent:* Scotland. *Fossil:* Scotland—Duntroon, Crinan, West Tarbert, Kyles of Bute, Kilchattan, Dumbarton, Dalmuir, Inch Lonaig; England—Bridlington; Canada.

Occurs in four of the Clyde gatherings—in three rare, and in one moderately common; in depths from 15 to 30 fathoms—bottom more or less soft.

BYTHOCYTHERE SIMPLEX, Norman.

Bythocythere simplex, Norman. Nat. Hist. Trans. Northumb. and Durh., vol. i, p. 17.
,, *acuminata*, G. O. Sars. Overs. Nory. Mar. Ostrac., p. 86.
,, *simplex*, Brady. Monog. Rec. Brit. Ostrac., p. 450.

DISTRIBUTION—*Recent:* Baffin's Bay, Norway, Great Britain. *Fossil:* Scotland—Duntroon, Lochgilp, West Tarbert, Cartsdyke, Paisley, Dalmuir, Govan, Jordanhill; Ireland—Woodburn.

Occurs in fourteen of the firth gatherings—in four rare, in seven common or moderately common, and in three abundant; in depth from 12 to 30 fathoms—the bottom more or less soft.

BYTHOCYTHERE CONSTRICTA, G. O. Sars.

Bythocythere constricta, G. O. Sars. Overs. Nory. Mar. Ostrac., p. 85.
,, ,, Brady. Monog. Rec. Brit. Ostrac., p. 451.

DISTRIBUTION—*Recent:* Great Britain, Ireland, Channel Islands. *Fossil:* Scotland—Tangyburn, Duntroon, Dumbarton, Govan.

Occurs in ten of the Firth of Clyde gatherings - rare in three, and common or moderately common in seven, but does not prevail in any; depth from 15 to 20 fathoms—bottom sandy mud. This species in some conditions is ready to be mistaken for *B. turgida*.

BYTHOCYTHERE TURGIDA, G. O. Sars.

Bythocythere turgida, Brady. Monog. Rec. Brit. Ostrac., p. 452.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland, Channel Islands.

Found in eleven of the Clyde district gatherings—in four rare, in six moderately common, and in one (Lochgoil) very common; 30 fathoms mud bottom—the least depth (Colintraive) 10 to 12 fathoms; bottom sandy mud.

PSEUDOCYTHERE CAUDATA, G. O. Sars.

Pseudocythere caudata, Brady. Monog. Rec. Brit. Ostrac., p. 453.

DISTRIBUTION—*Recent:* Norway, Great Britain, and Ireland. *Fossil:* Scotland—Blackburn, Dalmuir; raised beach, Oban. Ireland—Woodburn.

Occurs in nine of the gatherings in the Clyde district—in five rare, in three

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moderately common, and in one very common; and in depths from 6 to 26 fathoms, on ground more or less soft. The shell of this animal is pellucid, and generally of a dull lead colour; but in the gathering where they prevailed most (off De'il's Dyke, Cumbrae), the animal in the greater number was seen through the shell, giving it a fine tinge of brown or red, not over the whole but in patches shading away as they spread.

CYTHERIDEIS SUBULATA, Brady.

Cythere flavida, Baird.	Brit. Entom., p. 168.
Cytherideis subulata, Brady.	Monog. Rec. Brit. Ostrac., p. 454.

DISTRIBUTION—*Recent:* Britain, Ireland, Bay of Biscay, Cape Verde, Levant.

This species is generally rare in the Firth of Clyde, but at some places it prevails much. It occurred in eight of the Clyde district gatherings—in five rare, in one moderately common, and in two very common (the Clach and Portloy); in 5 to 8 and 10 to 12 fathoms, bottom muddy sand and shell debris. Between Portincross and Ardrossan it was found in 30 fathoms.

SCLEROCHILUS CONTORTUS, Norman.

Cythere contorta, Norman.	Ann. & Mag. Nat. Hist., vol. ix. p. 48.
Sclerochilus contortus, Sars.	Overs. Nory. Mar. Ostrac., p. 90.
,, ,, Brady.	Monog. Rec. Brit. Ostrac., p. 455.

DISTRIBUTION—*Recent:* Britain, Norway, Bay of Biscay, Spitzbergen. *Fossil:* Scotland, in nearly all the post-tertiary beds; South Wales, Cardiff New Dock-basin; Ireland, Belfast New Docks, Portrush; Norway and Canada.

A widely distributed species, and abundant both recent and in the post-tertiary deposits. It occurs in twenty-six out of forty of the Clyde gatherings—in twelve it is rare, and in twelve moderately common, and in two only abundant. The gatherings ranged from 6 to 30 fathoms, and on both hard and soft ground, but it prevailed most on the softer bottoms. In the gathering from Rothesay Bay, the tests were almost all of a fine yellowish-orange tint; others procured within tide mark on the Durham coast were mottled with dashes of black, in all probability arising from the condition of the animal or the character of its food, as such colours have not been noticed on the empty shell.

XIPHICHILUS TENUISSIMA, Norman.

Bythocythere tenuissima, Norman.	Brit. Assoc. Report, 1868, p. 294.
Xiphichilus ,, Brady.	Nat. Hist. Trans. Northumb. and Durh., vol. iii. p. 369.

DISTRIBUTION—*Recent:* England, Scotland.

This species occurs in thirteen of the Clyde district gatherings—in six rare, and in six moderately common, and in one (Callum's Bay, south end of Bute) abundant. These gatherings ranged from 10 to 30 fathoms, and on both hard and soft ground; but it was most frequent on muddy sand or mud.

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PARADOXOSTOMA VARIABILE, Baird.

Cythere flavida, Müller.	Entom., p. 66.
,, ,, Baird.	Trans. Berwickshire Club, vol. i., p. 98.
Paradoxostoma variabile, Brady.	Monog. Rec. Brit. Ostrac., p. 457.

DISTRIBUTION — *Recent:* Baffin's Bay, Spitzbergen, Great Britain, Norway, Holland. *Fossil:* Scotland—Tangyburn, Campbeltown, Duntroon, Lochgilp, Blackburn, Tarbert, Kyles of Bute, Cumbrae, Dumbarton, Cartsdyke, Greenock, Paisley, Govan, West Tarbert, raised beach, Oban; Ireland —Woodburn, Belfast New Docks; Norway; Canada.

This is one of the commonest species in the Firth of Clyde, but seldom occurring in any great abundance in one place. Of forty gatherings it occurred in thirty-five—rare in eighteen, moderately common in sixteen, and abundant only in one.

PARADOXOSTOMA ABBREVIATUM, G. O. Sars.

Paradoxostoma abbreviatum, Sars.	Overs. Nory. Mar. Ostrac., p. 94.
,, ,, Brady.	Monog. Rec. Brit. Ostrac., p. 458.

DISTRIBUTION — *Recent:* Great Britain, Ireland, Norway. *Fossil:* Scotland—Lochgilp, raised beach, Oban; South Wales, Cardiff.

Occurs in nineteen of the gatherings—in thirteen rare, and in six moderately common, but prevails in none. The depths of these gatherings ranged from 3 to 25 fathoms, both on hard and soft bottom.

PARADOXOSTOMA ENSIFORME, Brady.

Paradoxostoma ensiforme, Brady.	Monog. Rec. Brit. Ostrac., p. 460.

DISTRIBUTION — *Recent:* Great Britain, Ireland, Levant. *Fossil:* Scotland—Kyles of Bute; South Wales—Cardiff New Dock-basin (silt deposit); England—Bridlington; Ireland—Belfast New Docks (silt), Portrush raised beach.

Occurs in sixteen of the gatherings in the Clyde district—in ten rare, moderately common in five, and very common in one. Depth from 4 to 30 fathoms, both on hard and soft bottom.

PARADOXOSTOMA FLEXUOSUM, Brady.

Paradoxostoma flexuosum, Brady.	Monog. Rec. Brit. Ostrac., p. 461.
,, ,, B. & R.	Ann. & Mag. Nat. Hist., January, 1872.

DISTRIBUTION — *Recent:* Britain. *Fossil:* Scotland — Lochgilp; South Wales—Cardiff New Dock-basin, silt.

Not very common in the Clyde district, occurring only in fourteen of the gatherings—in ten rare, and in four moderately common; from 3 to 30 fathoms on various kinds of bottom.

PARADOXOSTOMA HIBERNICUM, Brady.

Paradoxostoma Hibernicum, Brady.	Monog. Rec. Brit. Ostrac., p. 460.
,, ,, B. & R.	Ann. & Mag. Nat. Hist., January, 1872.

DISTRIBUTION—*Recent:* Great Britain, Ireland.

Rather a rare species in the Firth of Clyde, occurring only in seven

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gatherings out of the forty—in six rare, moderately common in one (Kames Bay, Cumbrae, at low water). The others ranged from 4 to 20 fathoms.

PARADOXOSTOMA FISCHERII, G. O. Sars.

Paradoxostoma Fischerii, G. O. S. Overs. Nory. Mar. Ostrac., p. 96.
" " Brady. Nat. Hist. Trans. Northumb. and Durh., vol. iii., p. 362.
Sclerochilus gracilis, Brady & Rob. Ann. & Mag. Nat. Hist., ser. iv., vol. iii.

DISTRIBUTION—*Recent:* Britain, Ireland, Norway. *Fossil:* Scotland—Lochgilp, Cartsdyke, West Tarbert; South Wales—Cardiff New Dock-basin (silt); Ireland—Belfast New Docks.

Occurs in nine gatherings—in four rare, in four moderately common, and in one abundant. From 6 to 25 fathoms.

PARADOXOSTOMA PULCHELLUM, G. O. Sars.

Paradoxostoma pulchellum, Brady. Monog. Rec. Brit. Ostrac., p. 459.

DISTRIBUTION—*Recent:* Britain, Ireland.

This pretty little species is rare in the Clyde district. It occurs in six out of the forty gatherings—in three it is rare, in two moderately common, and in one common (Glen Sannox, in 20 fathoms, bottom mud); the others from 6 to 25 fathoms—bottom various.

PARADOXOSTOMA ARCUATUM, Brady.

Paradoxostoma arcuatum, Brady. Monog. Rec. Brit. Ostrac., p. 461.

DISTRIBUTION—*Recent:* Scotland and Ireland. *Fossil:* Scotland—raised beach, Oban.

Rare, only obtained in two of the firth gatherings—in one rare, and in one moderately common (Kilchattan Bay, 25 fathoms mud, and off the Lion, Cumbrae, 20 fathoms sandy mud).

PARADOXOSTOMA OBLIQUUM, G. O. Sars.

Paradoxastoma obliquum, G. O. Sars. Overs. Nory. Mar. p. 97.
" " Brady. Monog. Rec. Brit. Ostrac., p. 459.

DISTRIBUTION—*Recent:* Britain, Ireland, and the Channel Islands.

Rare in the Firth of Clyde, occurring only in four gatherings—one to three specimens in each; from 6 to 19 fathoms.

PARADOXOSTOMA ORCADENSE, Brady and Robertson.

Paradoxostoma orcadense, B. & R. Ann. & Mag. Nat. Hist., Jan., 1872.

This very rare species was hitherto only found in Stromness Bay, Orkney, now in Glen Sannox Bay, Arran, Firth of Clyde, moderately common.

It is a curious fact that this species has occurred only in two localities, and so far apart. The same is the case with *Cythere emarginata*, G. O. Sars, occurring in Britain only in Shetland and the Firth of Clyde.

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PHILOMEDES INTERPUNCTA, Baird.

Cypridina interpuncta, Baird.	Proc. Zool. Soc. Lond., part 18 (1850), p. 257.
Philomedes longicornis, Lillj.	De Crusta, p. 176.
„ *interpuncta*, Brady.	Monog. Rec. Brit. Ostrac., p. 463.

DISTRIBUTION—*Recent:* Britain, Ireland, Channel Islands.

Occurs in nineteen of the gatherings—in ten rare, in nine moderately common; depth from 5 to 30 fathoms. Most frequently on soft mud bottoms. This species often presents small round patches all over the shell; but those which are taken in the surface net are generally free of such patches.

ASTEROPE MARIÆ, Baird.

Cypridina Mariæ, Baird.	Proc. Zool. Soc. Lond., 1850, p. 257.
Cylindroleberis „	Monog. Rec. Brit. Ostrac., p. 465.
Asterope „ Brady.	Proc. Zool. Soc. Lond., April 4, 1871.

DISTRIBUTION—*Recent:* Britain, Ireland, Channel Islands.

Occurs in thirteen of the firth gatherings—in eleven rare, two moderately common; in depths from 3 to 30 fathoms, on various kinds of bottom, but most frequently on the soft mud. In the surface net after sunset it is taken abundantly.

ASTEROPE TERES, Norman.

Cypridina teres, Norman.	Ann. & Mag. Nat. Hist., vol. viii.
Cylindroleberis teres, Brady.	Monog. Rec. Brit. Ostrac., p. 465.
Asterope teres, Brady.	Proc. Zool. Soc. Lond., 1871, p. 295.

DISTRIBUTION—*Recent:* North Sea; West Coast of Scotland; Ireland; and Scilly and Channel Islands. *Fossil:* Scotland, Jordanhill.

This species in the firth gatherings occurs in four rare, and in one moderately common; in depths ranging from 5 to 20 fathoms. It is occasionally taken in the surface net, but neither so often nor so numerously as the preceding two species.

POLYCOPE ORBICULARIS, G. O. Sars.

Polycope orbicularis, G. O. Sars.	Overs. Nory. Mar. Ostrac., p. 122.
„ „ Brady.	Monog. Rec. Brit. Ostrac., p. 471.

DISTRIBUTION—*Recent:* Norway, Great Britain, Ireland, Spitzbergen. *Fossil:* Scotland—Duntroon, Dumbarton, Cartsdyke, Paisley, Old Mains, Govan, Dalmuir.

Occurs in eighteen of the firth gatherings—in seven rare, in seven moderately common, and in four very common. The range of depth in these gatherings was from 6 to 30 fathoms, bottom various; but in deeper water and on muddy bottoms they prevailed most, and there generally in the best condition. The translucent shell is often tinged with yellowish-brown, or in some instances with a delicate pink, but it is seldom that the two colours are met with in the same gathering. These colours have been noticed only when the shell contained the animal; they appear, in short, to be the colour of the animal transmitted through the shell.

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REMARKS ON THE LOCALITIES.

I.—LOCH RYAN.

Our dredgings were taken down the loch, two or three hundred yards off the Railway Pier, in 6 to 7 fathoms; bottom gravelly mud, with a number of dead shells. The usual method pursued with these dredgings was to take the most favourable looking haul for Ostracoda, Foraminifera, and other small organisms, and after washing and freeing it of the grosser material, put it aside for examination. When more was sought from the same locality to make up the desired quantity of material, it was taken close by on the same character of bottom.

It may be remarked that *Philina aperta* (Linn.) was in very great abundance at this place.

The Ostracoda were not so well represented as the appearance of the ground promised to be. Thirty-four species were obtained, and twenty-eight Foraminifera.

II.—OFF GIRVAN.

Our material was from about four miles off Girvan Pier, in 12 to 15 fathoms, on a bank of gravel and dead shells, which had a most unpromising appearance for Microzoa; yet on examination Ostracoda and Foraminifera were both unusually well represented; thirty-eight well-marked species of Ostracoda were found.

The Foraminifera exceeded the Ostracoda in the number of species, amounting to forty-four. Amongst them was a very fine specimen of *Lagena lagenoides*, (Will).

III.—CAMPBELTOWN LOCH.

The bottom of the loch is covered with mud, or sandy mud, nearly over its whole extent. The depth ranges from 6 to 10 fathoms, except towards the entrance, where the bottom gets harder, and the depth increases to 20 or 22 fathoms.

From the position and character of the surrounding hills, it is free from sudden gusts of wind, so dangerous in many of our western lochs. Spring tides rise only 8½ feet, and neap tides 6 feet, and their motions are so gentle that in many places they are scarcely felt. The general character of the loch is apparently so favourable to the habits of Microzoa that an unusually large gathering was expected. In this hope, however, we were to some extent disappointed. The list of Ostracoda amounted only to thirty-three species and Foraminifera to twenty-seven, seven of which were arenaceous forms.

It must be borne in mind that the gathering was only from one place near the head of the loch, and in all likelihood represents only a portion of the Ostracoda and Foraminifera of the loch.

IV.—EAST TARBERT.

Dredged off the Old Pier in 3 to 4 fathoms; bottom black sandy mud. The Ostracoda obtained were twenty-five species and the Foraminifera eighteen. None of either was of any special interest.

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V.—ARDRISHAIG.

The gathering was taken two or three hundred yards off the pier, farther up the loch, in 6 fathoms; bottom muddy sand, some little gravel and dead shells. The Ostracoda obtained were eighteen species, and Foraminifera only eleven. It may be mentioned that in a small ochreous streamlet near the head of the loch, *Quinqueloculina fusca* was abundant.

VI.—LOCHFYNE.

The gathering examined for Microzoa was taken off Inverary, towards Shira Point, in 25 fathoms, bottom soft mud.

This loch has been long famed for its Mollusca as well as its herrings. *Pecten septemradialis* is got in Lochfyne in great abundance, seldom in the dredge, but by means of a net spread over the ground that they frequent, to which they adhere till they are pulled up—as many as 800 have been taken in this way.

Terebratula caput-serpentis (Linn.) is plentiful and large in the loch where the bottom is gravelly. *Cylichna acuminata* (Brug), is common on mud bottom south side of the loch opposite Inverary. The rare *Emarginula crassa* (Sow.) has been occasionally dredged off Shira Point on gravelly bottom.

The Ostracoda obtained were forty-four species. *Cytheridea papillosa* (Bosq.) and *Cytheridea punctillata* (Brady), were both in fine condition and prevailed much.

Foraminifera, thirty-seven species. That of most interest was *Valvulina Austriaca* (D'Orb.) running into *V. conica*.

VII.—GLEN SANNOX BAY, ARRAN.

A great portion of the bottom of this bay is covered by coarse granitic sand, and very barren in Microzoa. On the east side of the bay, in deeper water (20 fathoms), where the bottom is sandy mud, life is more abundant, but still poor as regards genera and species. There were only seventeen species of Ostracoda obtained in the gathering. When species are few it often happens that rare forms are met with, and gatherings containing large numbers of species seldom yield much that is rare.

Amongst the Ostracoda from this place were, *Paradoxostoma pulchellum* (Sars), a moderately rare species, where it does occur being mostly only in twos and threes, but here it is moderately common; and *Paradoxostoma orcadense* (Brady and Robertson), still more rare, the only other locality in which it has been met with being the Bay of Stromness, Orkney. Foraminifera not examined.

VIII.—LAMLASH BAY, ARRAN.

The Bay of Lamlash is much resorted to as a good dredging ground. The field of operations being so near the village of Lamlash for a starting point is a great advantage, and the small but well-marked area of dredging ground is so well known to the native fishermen, and so rich in the various departments of the invertebrate fauna, that a successful day's work may at all times be calculated upon. It is different when the dredging ground has to be sought for at a distance of miles. The depth of the bay in general is about 14 or 15 fathoms. The bottom is variously covered by small gravel, Melobesia, shell

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debris, sand, and mud, supplying a diversity of haunts favourable to the different forms of animal life. Confining our remarks to those included in our present subject, the Ostracoda were in considerable profusion, numbering thirty-nine species; Foraminifera also thirty-nine.

IX.—HORSE ISLAND, NEAR ARDROSSAN.

The gathering was taken a little seaward of the island, in 20 fathoms; bottom sandy mud, with a small admixture of gravel and broken shells. Thirty-nine species of Ostracoda were obtained, and thirty-one of Foraminifera. Both were in very fine condition.

X.—BETWEEN PORTINCROSS AND ARDROSSAN.

The gathering was taken about three miles off shore, in 30 fathoms; bottom fine mud. This part of the shore is necessarily exposed to heavy seas, and yet the gathering was very rich, both in Ostracoda and Foraminifera, including forty-three species of the former and fifty-eight of the latter. Although this part of the coast is exposed to the south-west gales, its depth places it beyond the influence of the storm-waves, and the fineness of the mud is evidence that it is not much exposed to undercurrents, and may maintain a calm more favourable to the development of these minute organisms than the apparently sheltered lochs, where the tides, streaming between their narrow sides, scour the bottom every ebb and flow. Yet in some of these lochs where a paucity of Ostracoda and Foraminifera may be remarked, the bottom is covered with mud.

XI.—ST. NINIAN'S BAY, BUTE.

The gathering from this place was taken in 6 to 7 fathoms, on a sandy gravelly bottom. Amongst the material brought up there was little appearance of either animal or vegetable life. The gravel was clean and smooth, evidently from rolling on the sea bottom. The Ostracoda obtained were twenty-eight species. *Cytherura gibba* (Müller), rather a rare species, was abundant and in fine condition.

The Foraminifera numbered thirty-two species. The sculptured *Lagenæ* were well represented; amongst them *Lagena sulcata* (W. & J.) was very fine. The smooth forms, as *Lagena lævis* and *L. gracillima*, were entirely absent.

XII.—LOCH RIDUN.

The bottom of this loch, over its greater extent, is covered with mud and muddy sand. Our gathering was taken about half way up the loch in 16 fathoms, and contained twenty species of Ostracoda. *Cythere tenera* (Brady) and *Cytheridea papillosa* (Bosquet) prevailed most.

Foraminifera were better represented in numbers (twenty-eight), and contained a few beautiful specimens of *Lagena striata* (Montagu), and *Lagena Lyellii* (Sagz.); and it may be noticed that a very fine specimen of the Mollusc *Neæra cuspidata* (Olivi) was obtained at the same place.

XIII.—COLINTRAIVE BAY.

The bay on the north side deepens to 10–12 fathoms; bottom sandy mud, mixed with a little gravel. The Ostracoda obtained were thirty-

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one species; some that in most other places are rather rare, were here moderately common; such as, *Cythere antiquata* (Baird), *Cythere Jonesii* (Baird), *Bythocythere constricta* (Sars), *Xiphichilus tenuissima* (Norman), and *Polycope orbicularis* (Sars).

Foraminifera were rather more numerous (thirty-seven species), amongst them *Lituola nautiloidea* (Lamk.), *L. scorpiurus* (Montfort), and *Nodosaria scalaris* (Batsch) were very fine.

XIV.—LOCH STRIVEN.

The gathering was taken near the foot of the loch, in 26 fathoms, mud bottom; and another gathering about four miles further up, in 20 fathoms, mud mixed with a little sand and gravel. The two gatherings did not differ much, and between them twenty-nine species of Ostracoda were obtained, and thirty-one of Foraminifera. There was nothing in either of unusual interest.

XV.—ROTHESAY BAY.

The gathering was taken from opposite the pier, out towards the entrance of the bay, in 15 to 18 fathoms. Bottom brownish mud mixed with gravel and numerous dead shells. *Astarte sulcata* and *compressa* were common, mostly large in size, and all dead, having much the appearance of those from post-tertiary deposits. That they were so is all the more likely, as Dr. J. Grieve dredged a valve of *Pecten Islandicus* in the same locality. Both the Ostracoda and Foraminifera of this gathering must therefore be taken with some reserve, although they do not exceed gatherings obtained in similar localities. The number of species of Ostracoda noticed was forty-three, but few prevailed much individually. The Foraminifera were nearly the same in number, forty-one species, but much more abundant individually. *Nodosaria scalaris* (Batsch) was common.

XVI.—KILCHATTAN BAY, BUTE.

This bay, between tide, is chiefly muddy sand; but as the water deepens the bottom becomes more and more muddy. Our gathering was taken in 20 to 25 fathoms, bottom mud, with a small admixture of sand. Both Foraminifera and Ostracoda were well represented—forty-four species of the former, and forty-six of the latter. Amongst the Ostracoda, *Cytheropteron alatum* (Sars) was common in various stages of growth. Among the Foraminifera the *Lagenæ* were very fine; *Lagena Jeffreysii* especially was of great beauty, and far from being rare.

XVII.—GLEN CALLUM'S BAY, BUTE.

The gathering was taken about two hundred yards out from the bay towards the lighthouse, Little Cumbrae, in 19 fathoms; the bottom shelly mud, gravel, and Melobesia. The Ostracoda obtained were forty-seven species, and Foraminifera thirty-six. The number of species was amongst the highest, particularly of the Ostracoda. That of most interest amongst the Foraminifera was *Trochammina gordialis* (P. & J.)

XVIII.—LITTLE CUMBRAE.

The material was dredged in 3 to 5 fathoms, on the east side of the old castle; the bottom shelly debris, which had a very unpromising appearance.

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Still the Ostracoda were moderately well represented, numbering twenty-eight species. Amongst them was *Bairdia inflata* (Norman), a rare species in the Clyde district. *Loxoconcha impressa* (Baird), the only species of the genus noticed at this place, was the most abundant in the gathering.

Foraminifera twenty-seven species. *Polystomella crispa* (Linn.) prevailed, and was in fine condition.

XIX.—MUGGIE POINT

(North-east end of Little Cumbrae).

The gathering for Ostracoda and Foraminifera was taken about 150 yards off shore, in a north-easterly direction, in 16 fathoms, on a gravelly bottom. This place was remarkable for the number of *Comatulæ* of all sizes that the dredge brought up; dozens were in the dredge, and dozens were hanging on the net and rope outside. At another haul about the same place, a long old frond of *Laminaria saccharina* (Linn.) was drawn up, hoary with hundreds of *Pentacrinus Europæus* (Forbes) (the young *Comatula*).

The Ostracoda obtained were thirty-seven species; none in any great number or of special interest.

XX.—THE TAN.

This is off the south end of Great Cumbrae. The buoy marks the edge of a bank of Melobesia, which has long been resorted to by naturalists for dredging operations. *Lima hians* (Gm.) and their nests are very abundant on this bank, especially on the west and south side of the buoy. The material examined for Ostracoda and Foraminifera was taken a little on the outside of the buoy in 10 to 12 fathoms, bottom Melobesia and mud; forty-four species of Ostracoda were obtained, none prevailed much. Foraminifera were still more numerous (forty-nine species). *Quinqueloculina secans* (D'Orb.) and *Q. bicornis* (W. & J.) were abundant, and in very fine condition. The *Lagenæ* were numerous, and many of great beauty; amongst them was *Lagena striata-punctata* (P. & J.). *Patellina corrugata* (Will.) was also abundant and fine.

XXI.—CLACH.

This is the smallest and most westerly of a small group of rocks or islets in Millport Bay. On the north side, or between the rock and the shore, is excellent dredging ground, where Mollusca, Crustacea, and Algæ, are common, and it has the advantage of easy access. The ground may be dredged close by the rock on the north side, where it is chiefly mud and shell debris; but farther shoreward it gets more gravelly, and much grown over with sea-weed. Here Crabs of various kinds are common. As the north shore is neared, the ground gets too rough for the safe working of the dredge. On a line from the north-west end of the rock, in the direction of the west end of Crighton Street, till the lower end of the rock is cleared, we have found to be the richest part of the ground. The depth is from 5 to 8 fathoms. The Ostracoda obtained at this place were forty-six species. *Cythere badia* (Norman), a rather rare form in the Firth of Clyde, is common here. *Cythere crispata* (Brady) is also common, and both in very fine condition. Foraminifera, forty-nine species. Amongst them is *Trochammina squamata* (P. & J.)

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XXII.—KAMES BAY, CUMBRAE, AT LOW WATER.

Many good gatherings are made in tide pools between high and low water, but the present is of a different character, and refers to some very interesting and productive gatherings obtained by scraping off the muddy sand on stones and rocks at the verge of low water. These mud-covered stones at low water are generally found to be overgrown with minute species of Algæ, as *Callithamnion Rothii*, &c., and are favourite retreats for Entomostraca and Foraminifera. Of Ostracoda twenty-five species were obtained. As the gatherings in this paper are confined to the dredge, this one from the tidal belt has been introduced as a sample of what may be got on such places.

XXIII.—PORTLOY, CUMBRAE.

A small creek on the east side of Kames Bay, where the stones between tide mark are heaped up against each other, leaving hollows between, where a great profusion of the invertebrate fauna find shelter. At spring tides, by turning over the stones, excellent captures are made. In the early months of the year it is quite a den for the *Nudibranchs*. The creek is small and rather rocky inside, but outside, in 10 to 12 fathoms, on a bottom of sandy mud and small gravel, rich gatherings of Microzoa may be obtained. In one of these, forty-seven species of Ostracoda occurred. *Cytherura cellulosa* (Norman) and *Cytherideis subulata* (Brady) were amongst the prevailing species. *Paracypris polita* (Sars), a rather rare species both in distribution and individuals, is here moderately common.

Foraminifera thirty-nine species. Those prevailing were *Biloculina ringens* (Lam.), *Quinqueloculina subrotunda* (Mont.), *Verneuilina polystropha* (Reuss), and *Polystomella crispa* (Linn).

XXIV.—FAIRLAND POINT.

This is at the south-east corner of Kames Bay, where the sea, for some distance off shore, is generally more or less tumultuous.

The material for examination was dredged about 300 yards to the south, the bottom small gravel and muddy shell debris. The Ostracoda obtained were thirty-six species, the most noteworthy being *Cytherura producta* (Brady), hitherto considered a rare species; here moderately common. In another gathering a little farther to the west, in 14 fathoms, on a similar bottom, it was not found—this, as has been remarked, is a common occurrence.

XXV.—CAPEL ROCK.

A large exposed trap dyke on the south side of Cumbrae, locally known by the name of "De'il's Dyke."

The gathering was dredged at about 60 yards off shore, in 10 to 15 fathoms; the bottom muddy shell debris. Forty-three Ostracoda were obtained. *Pontocypris mytiloides* (Norman) was common, and most of them, instead of the usual purplish colour, were of a fine full brown; also *Pseudocythere caudata*, usually of a dull lead colour, was patched over with brownish-red. *Sclerochilus contortus* (Norman) prevailed greatly.

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XXVI.—LION ROCK, CUMBRAE.

The gathering was taken in about 150 yards off the rock, in 20 fathoms; bottom mud. Ostracoda forty-three species; Foraminifera thirty-seven species.

XXVII.—FAIRLIE PERCH.

The perch is placed on the edge of a broad spit of sand a little below Fairlie, on the Ayrshire coast. The gathering was taken at a little distance off the perch, in 10 fathoms; bottom sandy. There was nothing remarkable in the gathering. *Cythere villosa* (Sars) prevailed most. The number of species of Ostracoda obtained was thirty-five.

XXVIII.—FERRY HOUSE, CUMBRAE.

The gathering was taken a little west of the pier, in 6 fathoms; bottom sandy mud. Thirty-four species of Ostracoda were obtained; some moderately common, but none in great abundance. *Cythere tenera* was of a fine brown colour, without the porcellaneous character which prevails amongst those found in the same neighbourhood on a softer bottom and in deeper water.

XXIX.—OFF LARGS.

In 20 fathoms; bottom dark-coloured slimy mud. Neither Ostracoda nor Foraminifera were numerous in species. Twenty-five species of Ostracoda were obtained; *Cytheridea papillosa* the most abundant, and in beautiful condition. *Cytheridea punctillata* was common, but not so fine as *C. papillosa*. *Krithe Bartonensis* and *Cythere tenera* were moderately common. Many of this last species were more or less porcellaneous, which I have sometimes noticed occurring on the same character of ground.

Foraminifera twenty-nine species. Amongst them *Bolivina plicata* (D'Orb).

XXX.—WHITE BAY, CUMBRAE.

(North-east End of Cumbrae.)

The gathering was made in 20 fathoms; bottom sandy mud. The number of species of Ostracoda obtained was thirty-one. There was little or nothing remarkable amongst them. The most noteworthy was the state of *Loxoconcha impressa*, the specimens of which were all greatly eroded. *Polycope orbicularis* was common. Foraminifera, thirty-seven species.

XXXI.—WHITE BAY, CUMBRAE.

Another gathering was taken nearer to the shore, in 2 to 7 fathoms, which will be seen in the table to differ much from the other.

XXXII.—OFF FIGGETOCH GLEN, CUMBRAE.

In 22 fathoms; bottom sandy mud. It is remarkable that this gathering does not contain a single species of the genus *Cytherura*. *Cythere tenera* is common; *Cytheridea punctillata* is more abundant than *Cytheridea papillosa*, which is generally the reverse on a muddy bottom (*C. punctillata* is more

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attached to ground somewhat harder). Ostracoda twenty-five species; Foraminifera thirty-nine species, amongst the latter *Lagena Jeffreysii* (Brady) was very fine.

XXXIII.—FINTRY BAY, CUMBRAE.

This is a long sandy bay on the north side of the island, more or less gravelly at some points.

The gathering was taken in 22 fathoms, about half a mile off shore, beyond the sand bank, in sandy mud. Thirty-four species of Ostracoda were obtained, *Cytheridea papillosa* and *Cythere tuberculata* prevailing, as they generally do on muddy bottoms. *Polycope orbicularis* was moderately common, and beautifully tinged with red. Foraminifera forty-two species. Amongst them was the rare *Lagena pulchella* (Brady).

XXXIV.—INVERKIP BAY.

The haul taken to be examined for Ostracoda and Foraminifera was in 12 fathoms; bottom mud, mixed with small gravel and broken shells. Thirty-five species of Ostracoda were obtained, mostly well represented. *Cytheridea papillosa* prevailed greatly, *Polycope orbicularis* was common, and mostly marked with a fine dash of red.

Foraminifera were more numerous, forty-three species. *Polymorphina tubulosa* was remarkable in this gathering for its large size and wide-spreading branches, and also a fine specimen of *Rotalia nitida* (Will.)

XXXV.—LOCH LONG.

The gathering was taken off Coulport Ferry, in 15 fathoms; bottom muddy, sandy gravel. Forty-three species of Ostracoda were obtained. *Krithe Bartonensis* (Jones) and *Philomedes interpunctata* (Baird) were very abundant; *Argillæcea cylindrica* (G. O. Sars), a rather rare species, was common. Foraminifera twenty-five species.

XXXVI.—ROSENEATH BAY.

This gathering was made towards the pier on the opposite side, in 10 to 15 fathoms; bottom mud. *Cytheridea papillosa* and *Cythere Dunelmensis* prevailed greatly, as they do in the neighbouring loch, and also *Loxoconcha granulata*. *Bythocythere simplex* was moderately common, and most of the specimens had a fine dash of red towards the anterior extremity.

In a haul nearer the shore, in 2 fathoms, on a sandy bottom, *Cythere pellucida*, *C. porcellanea*, *C. lutea*, and *Eucythere declivis* were common, but absent in that from the deeper water. It may be remarked that here *Cythere porcellanea* was in exceptionally fine condition, and of the true typical form.

These four species, in 2 fathoms, have been placed in the list with those from 10 to 15 fathoms. Ostracoda forty-five species. The Foraminifer, *Verneuilina polystropha* (Reuss), was in excessive abundance.

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It may be noticed that *Virgularia mirabilis* is very common in this bay both in the deep and shallower water, on mud bottom, but none of large size. *Psolus Phantapus* (Linn.) is also moderately common between Roseneath and the Row Pier.

XXXVII.—OFF GREENOCK.

The gathering was made about a mile from the pier in the direction of Roseneath, in 4 to 6 fathoms; bottom muddy sand. There is not much of interest amongst the Ostracoda, further than they connect the animals of stronger marine habits with the more brackish forms of Port-Glasgow and Langbank; and they further prove that the south side of the firth at this place is greatly more brackish than the north. This is contrary to a popular belief that the sewage of Glasgow is carried down by the Clyde, and deposited along the shores of Helensburgh and in Roseneath Bay. The gatherings from these latter places scarcely shew a vestige of brackish water forms; while on the Greenock side many of them are decidedly brackish—as *Cythere castanea*, *Cytheridea torosa*, and *Cythere gibba*, and some obviously washed down from the upper reaches of the Clyde, as *Cypris compressa*, *Cypridopsis obesa*, and *Candona albicans*. Ostracoda twenty-three species.

XXXVIII.—PORT-GLASGOW AND LANGBANK.

We may quote here the description given of this place in a paper "On the Ostracoda and Foraminifera of Tidal Rivers," by Brady and Robertson. *Ann. and Mag. of Nat. Hist.*, July, 1870.

"At Langbank the tide leaves bare a long muddy flat along the river, nearly a quarter of a mile broad; and when the tide is out, and the river swollen to any extent, this is covered by fresh water. Our gatherings at this place were taken from low water to near high water mark. Other gatherings were taken from Port-Glasgow up along the river for fully a mile, in 4 to 8 feet water, beyond low tide. In some places the bottom is soft black mud; in others, muddy, gravelly sand, much covered by mussels (*Mytilus edulis*).

"The estuary here is a few miles broad, and the tide rises from 8 to 10 feet, the fresh water being much less felt than at Langbank, which is about 4 miles farther up, where the water narrows greatly as it reaches Dumbarton Castle. It is somewhat remarkable, considering the extent of the gatherings, the diversity of bottom, and the very promising appearance in every way of the locality, together with the profusion of *Coraphium Isopoda* and other forms of animal life, that the Ostracoda and Foraminifera met with were exceptionally few, both in the number of species and individuals, and those mostly of brackish or fresh-water type. We are disposed to think that the great amount of chemical refuse poured into the River Clyde from around Glasgow and Paisley may be the chief cause. In the River Wear, where somewhat similar conditions exist, we have found the fauna affected exactly in the same manner. That some artificial cause is at work seems almost certain, as we have not found so poor a microscopic fauna in any river unconnected with manufacturing operations."

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As many of the species of Ostracoda belong to fresh water, probably having been washed down from the higher reaches of the river, which our table does not admit, subjoined is a list of all the species met with—

Cypris compressa, Baird. ×
Cypridopsis obesa, Br. & Rob. ×
Potamocypris fulva, Brady. ×
Candona albicans, Brady. ×
,, *detecta*, Müller. ×
Cythere pellucida, Baird. ×
,, *castanea*, Sars. × ×
,, *viridis*, Müller. × ×
,, *villosa*, Sars. ×
Cythere angulata, Sars. ×
Linnicythere inopinata, Baird.
Cytheridea papillosa, Bosq. ×
,, *torosa*, var. *teres*. × ×
Eucythere argus, Sars. ×
Loxoconcha fragilis, Sars. ×
Cytherura Robertsoni, Brady. ×
Paradoxostoma variabile. ×

XXXIX.—LOCHGOIL.

The gathering was taken off Aird Madaila in 30 fathoms, mud bottom. Neither Foraminifera nor Ostracoda were numerous—twenty-four of the former and thirty-four of the latter. Some of the more common, and a few of the rarer species were in considerable abundance and in good condition, as they generally are, wherever they are found prevailing;—such as *Loxoconcha granulata* (Sars), *Cytheropteron alatum* (Sars), *Bythocythere simplex* (Norman), and *Polycope orbicularis* (Sars).

A gathering a little farther up the loch in 12 fathoms, bottom sandy mud, was much poorer in Microzoa, and had few or none of the rarer forms found so plentifully in that of 30 fathoms.

XL.—GARELOCH.

The gathering was taken in 15 fathoms, near the upper end of the loch. The bottom was fine brown mud, with a little small gravel and sand. The species of Ostracoda obtained were thirty-one. Amongst those that prevailed most were *Cythere tenera* (Brady), *Cytheridea papillosa* (Bosq.), *Loxoconcha granulata* (Sars), *Cytheropteron latissima* (Norman), *Bythocythere simplex* (Norman)—most of these shells contained the animal, which added greatly to their beauty. *Cythere tenera* in this gathering had a tendency to a porcellaneous test. *Cythere Dunelmensis* and *Cythere tuberculata* were also common, but not in very good condition. In another gathering near the head of the loch, in 4 to 5 fathoms, muddy bottom, *Cytheridea papillosa* occurred, but in nothing like the numbers that were found a little farther down the loch in 15 fathoms, where they were in great excess. On the other hand, *Cythere Dunelmensis* was greatly more abundant in 4 to 5 fathoms than they were in the deeper water.

Foraminifera nineteen species.

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In connection with the foregoing lists, it may be of use to append a few short notes on the appliances for collecting the Ostracoda and Foraminifera, and on the preparation of the specimens. For further particulars, see an excellent paper by my friend, G. S. Brady, on collecting and preserving Microzoa (*Nature*, vol. viii., p. 63).

Marine Microzoa may be collected by the hand net amongst the tangle, by the surface net, and by the dredge. The latter, however, is by far the most successful means. The dredge, as usually made, is so large and difficult to transport and work, that its use is mainly confined to special occasions requiring much troublesome preparation. As a large dredge is not required to secure these small animals, nor a large bag to hold the material that need be brought up from the sea bottom for examination, I have had a small instrument made, which is found to answer the purpose exceedingly well.

This dredge, with a rope sufficiently long to be worked in forty or fifty fathoms of water, will not exceed 10 or 12 lbs. in weight, and all can be packed in a small basket, and made available at any time when a few hours can be spared at the sea-shore. Any one, moreover, who can use the oars of a boat can manage it by himself if required; and it is surprising what can be done in this way by a single person working at his leisure. The dredge itself is of the usual form, and weighs 4 lbs.; the mouth is 7 inches long by 3½ inches wide; the arms, 4 inches long, are jointed to the lower ends of the frame, admitting of motion only transversely to the mouth. This is a contrary arrangement to the common dredge of the naturalist, on which the arms move inwards along the mouth, and not having the transverse motion, are apt to exercise a leverage in a direction to lift the scraper off the ground, which must be a frequent cause of vexatious disappointment in dredging.

The bag used on the small dredge requires to be sufficiently fine to retain the small animals sought for, and open enough to allow the water to run off freely. The thin cloth known by the name of "cheese cloth," answers the purpose very well, when made to suit the circumference of the dredge, and not less than 30 inches long. The advantage of this great length of bag in proportion to the size of the dredge will be seen, when we consider the tendency that the material has in a short bag to wash out when the sea is in some degree rough. I have found the same form of bag to be equally applicable and efficient with larger dredges. The lower end of the bag is not sewed, but tied with a cord, by which it can be opened and emptied more easily than by the mouth. A stone of two or three pounds weight attached to the lower end of the bag keeps it in good position on the sea bottom, and allows it to fill the more readily. This is managed with little trouble by putting the stone in a small bag or net, and fixing it to the lower end of the dredge bag by a running noose, which does instead of tying the bag with a separate cord. Where the water is deeper than 5 or 6 fathoms, or the sea rough, it is necessary to attach a stone in the same way to the rope 2 or 3 fathoms forward from the dredge, in order to counteract the buoyancy of additional rope, and keep the mouth of the dredge to the ground, the weight requiring to be increased according to the increase of depth or strength of current.

This little dredge has been found exceedingly efficient for the capture of the smaller forms, and the richness of the hauls that have been taken with it has often been a matter of wonder. Although so light and portable, it is sufficiently large to admit, with the exception of a few of the larger and

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commoner things, almost everything on our coasts of interest to the naturalist; and in this belief it has been successfully used for days together in general work, in preference to larger dredges. Indeed, knowing what a very small dredge can do, and the great saving of labour in working, I would not think of using one in a rowing boat larger than 10 or 12 inches, except for some special purpose.

To prepare the dredged material for the separation of the minute organisms, it is necessary to have in the boat a tub or pail filled with water, and to wash the dredged material into it through a sieve, of about one-eighth inch meshes, which will allow all the Microzoa to pass into the water. Many of these will be found floating on it, chiefly *Amphipoda*, *Copepoda*, &c., with some of the smooth-shelled Ostracoda, which can all be collected expeditiously by pouring the water through a muslin bag sufficiently fine to retain the animals, after which they are washed by pouring clean water over them. Then they should be transferred to a bottle containing spirits for preservation, care being taken to label it with the name of locality, depth of water, and character of bottom.

The material at the bottom of the tub is next washed in the muslin bag* over the side of the boat till the water runs off clear. Thus cleaned, it is transferred to a small cotton bag—about 10 inches deep by 7 broad is a size that suits very well. When this material has to remain in the bags for some time, as often it has to do before being dried and examined, the animal tissues of the Ostracoda are in almost every instance found to be destroyed, to the loss of that which often affords the only characteristics that can be relied upon to determine the affinity or place of any that may be doubtful or new.

As the quantity of material usually bagged up in this way would be expensive and inconvenient to carry in spirits, I have found that common table salt answers admirably as a preservative to mix up in the bags. In doing this another advantage has been unexpectedly found—viz., when mixed with peaty mud the salt, by entering thoroughly amongst the particles, causes it when dry to dissolve readily in water and sink to the bottom, leaving the Ostracoda and Foraminifera with their usual tendency to float, whereby they can easily be secured. On the other hand, dried peaty mud not treated with salt, when put into water floats altogether, and it is therefore exceedingly difficult to separate the Microzoa from it. We next label as before described, but in this case it is more difficult to do it securely, as both bag and contents are wet, and may have to be packed together in that state for some time, which would necessarily destroy all ordinary labels, whether placed in or outside of the bag. To obviate this we enclose the label in a small wooden needle-case (to be had for threepence or fourpence a dozen), which I have never found to fail, although lying for weeks together in soft mud.

The surface net is another successful means of capture, especially after sunset, but not for either Ostracoda or Foraminifera, except a few of the

* In this case the fabric of the bag requires to be a little finer than that last used, so that none of the minute Foraminifera may escape. A suitable kind of cloth is that known by the name of "Scotch lawn," of the fineness of 26 or 28 cross threads under the draper's glass. The bag may be made about 18 inches deep and 9 inches wide, rounded at the bottom—5 or 6 inches of stout cotton cloth next the top makes it more convenient to work with. It is a great protection to the fine bag when working, to have it within a stronger bag of open texture, when it can be used with more safety and freedom—a strong canvas loose cover is equally useful over the dredge bag.

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family *Cypridinidæ*, though often rich in *Amphipoda*, *Copepoda*, &c. Unlike the dredge, with which you may return to ground where you have been successful, with every prospect of obtaining similar good gatherings, the surface net is often disappointing in this respect, as the play or feeding ground of these animals is so changeable, that some nights in passing over the same area where they had been abundant on a previous night, scarcely one is to be found. It often happens that the group taken in the net one night, is very different from that gathered on the following over the same surface. The darker the night and the more luminous the water, the more hopeful it is of success.

There have been many different shapes and sizes of surface nets, but whatever these may be, one thing must be kept in mind—viz., that the mouth of the net must not take in more water than the meshes can freely let out, otherwise the contents will be thrown out by the back water as fast as they come in. There is reason to believe that this has been a cause of frequent disappointment in the use of the surface net. The one I have found most successful and convenient in the rowing-boat is about 10 inches in diameter, and 20 in depth; and as the class of animals taken by the surface net is not so minute as those obtained by the dredge, the net need not be so small in the mesh as that used for washing the mud. The same fabric "Scotch lawn," but coarser, answers very well. The bag is rounded at bottom, and secured by a brass ring at the mouth, strong enough to bear the resistance of the current of water when at work, and a small hose is attached to the ring to receive the handle or walking-stick. A little tin can is required, not less than 6 or 7 inches in diameter, and about 8 or 9 inches deep, half filled with sea water. The net is held over the boat a few inches in the water while it is moving gently along for about 40 or 50 yards; it is then lifted, and, putting the hand to the bottom of it, inverted into the can of water, so as to wash off the captures. It is then withdrawn to its former position, and the process repeated.

When brought home, the contents are best seen when emptied into a white basin, and if anything special appears, it can be put by itself for safety or further examination; the whole may be washed through a coarse sieve to separate the larger impurities, in the same way as the dredged material was washed. Another mode of collecting is by washing in a tub of water the dredged tangle or small Algæ scraped from the rocks in tide pools or at low water—the animals being secured as before described. The same process of washing and straining may be applied with great success to sand or mud taken from low-water mark, which can be managed with smaller vessels than required for the tangle.

Returning to the dredged material that was packed in the bags, the next process is to dry it well; then transfer it to a vessel with water, stirring it thoroughly afterwards; skim off all that floats on the surface, which will contain most of the Microzoa and many of the minute shells, &c. This should be laid on a fine sieve, then more water added to the vessel, and all the sediment again stirred up from the bottom, and the skimming repeated in this way for several times, till all is gathered that floats on the surface after repeated stirrings. Clean water should then be run on the contents of the sieve until freed of all the loose impurities; the residue is then dried and is ready for further examination. The material thus obtained is called "floatings."

In this operation, although the greater number of the Microzoa float, yet

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many of them do so only partially, especially the rough, heavy shelled Ostracoda, as *Cythere Dunelmensis* and *C. tuberculata*. In some cases it may, therefore, be necessary to re-dry and float again, or examine the material itself in mass; but where there is a fair quantity to work upon, this need hardly be done.

The next operation is to examine the floatings, which is best done by sifting them through two or three sieves of different sizes; the first to retain the larger forms, and so on, whereby the different grades can be more easily examined, as the larger do not then so readily obscure the smaller forms. We then spread a small quantity on a writing slate, and with a hand lens and small hair pencil pick out those required, which may be transferred to small separate tablets for the different species.

Searching for very minute forms is best done under the microscope with a low power. The work is much facilitated by drawing lines on a slip of thin black cardboard, suitable to the field the instrument will take in, and following between the lines up and down, which guides the eye over the whole material to be searched, without the risk of traversing by haphazard the same surface that has already been gone over.

MOUNTING.—Objects mounted to be viewed by transmitted light are best seen on a black ground, and for this purpose slides made of cardboard are now in general use for the microscope, and are both convenient and safe for transmission by post, offering great facilities for exchange. They are also cheap, and where not readily to be bought are easily made.

Any paperbox-maker will cover a sheet of cardboard (of proper thickness to suit the objects to be mounted) with paper of the colour desired, and another sheet of cardboard with black paper, cutting both sheets into slips 3 inches long by 1 broad. Let a hole be then punched in the coloured slip of a convenient size to form the cell,* and paste it on the black slip, pressing till dry, and the slide is complete.

The objects to be mounted are now placed in the cell with a little gum-arabic, or two parts of gum-arabic and one part of gum-tragacanth. The addition of a few drops of glycerine makes it less brittle when dry. Those mounted for the cabinet are kept more safely, and can be examined with more freedom, when covered with glass.

THE POST-TERTIARY clays are treated precisely as the dredged material—that is, dried, dissolved, and floated for Microzoa, and when wanted, the residue is washed free of the mud, and re-dried and examined for shells and other animal remains.

SHALES.—As the Ostracoda and Foraminifera of the shales do not float, that material when soft and clayey requires only to be washed through a fine sieve (close enough to retain all the Microzoa) till the water runs off clear, then dried, and the coarser material removed by a sieve, and the finer siftings examined by the hand lens or microscope.

These soft shales are often examined by mixing them well in plenty of water, letting it stand a minute or two to allow the Microzoa to subside; then pouring off the muddy water, repeating the process till clean.

Ostracoda embedded in hard shale, lime, or ironstone, are often successfully liberated from their matrix by the concussion in breaking these materials into small pieces.

* Round punches of any size may be had from the gunsmiths, which suits very well. Other shapes are made to order.

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VIII.—Notes *from the* Island of Bute.
By David Corse Glen, C.E.

I.—On a Tract of Columnar Sandstone, and a Perched Boulder, near Kilchattan.

[Read 11th Dec., 1873.]

The tract of columnar sandstone which forms the subject of the following remarks, I have thought of sufficient interest to bring before this Society. Although known to the Rev. Mr. Macbride, and a few other residents in Bute, yet no account, that I am aware of, has hitherto been given of the section, nor has it been noticed by Dr. Bryce when describing the other geological features of the island.*

The first time I observed this section was in 1869, when landing in a small boat from a steam yacht with a pic-nic party. It was so striking in appearance, that even the non-geologists of the company compared it to a miniature Giant's Causeway; and the remarkable feature is that the rock is columnar sandstone, and not trap, and that no trap appears in the neighbourhood, nor for some distance along the shore. I had previously passed along the shore from Glencallum Bay to near this point, and made a small collection of the rocks, many of which are peculiar and very interesting. They are mostly igneous, and appear to have been ejected from some volcanic vent in the neighbourhood.

The section lies about half a mile south of Kilchattan pier, and immediately beyond the first fence dyke, across the road leading along the shore southwards. It is about four or five yards wide, and extends from below high-water mark up to the cliffs, which lie about forty yards inland. The strata here dip from the sea towards the cliff, at an angle of about 25° to 30°.

The best developed tract of this columnar sandstone is near

* Dr. Bryce remarks with regard to Bute—"It has many points of great interest; strata occur here to be met with nowhere else in Scotland, and the effects of its trap dykes upon the adjoining strata are extremely curious—indeed of a unique character. . . . The portion extending from Rothesay Valley to Kilchattan is occupied by red sandstone; and finally, the southern portion, with a substratum of red sandstone, consists mainly of various rocks of the trap family, erupted through and overlying the sandstone."—*Geol. of Arran, &c.*, p 316-17, 4th Ed.

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high-water mark, and is about four or five yards square. In the centre of this space there is a fissure, which at first appears to be a dyke; but on removing the loose materials washed up by the tide, no trap is to be found, and the columnar structure is only observable for a few feet on each side of this centre.

The columns are all nearly vertical, none being more than twenty degrees from the perpendicular. Their size varies from six or seven inches in diameter down to half-an-inch. Some of the large columns break into smaller ones from exposure to the weather, and others branch into two, forming twin columns. The number of sides varies from four to eight or ten, six being the most common.

Heat was no doubt the agency by which the sandstone was made to assume the columnar form along this narrow tract; but the source and nature of the heat, and the conditions under which it acted, are the points to be ascertained and answered.

Had a sheet of lava overflown the sandstone at this point, we might expect to see its effects over a wider area of rock than the narrow strip of columnar sandstone which has been described. We might also look for some trace of this bed of igneous rock overlying the sandstone in the cliff, but such does not occur. I am inclined, therefore, to think that the sandstone has been rendered columnar by steam, or some other highly heated vapour, passing upwards through a vertical fissure in the rock, and which has altered the sandstone to a certain distance on each side. Beyond that point, a distance of some six or seven feet, the rock retains its normal character of a bedded red sandstone.

It is well known that in the neighbourhood of recent volcanoes there are sundry fissures through which steam and other heated gases escape to the surface; and as we have abundant evidence of igneous action in Bute, I think it highly probable that the phenomenon in question has been produced in this manner.

A few notes of a more general kind on columnar structure may here be added. This structure is developed in both igneous and sedimentary rocks: in the former it is the result of cooling under certain conditions from a fluid to a solid mass; in the latter, it is the result of long-continued heat acting upon a mass of solid strata. In the cooling of a mass of basalt, or any other igneous product, which has a tendency to assume the columnar form in passing into the solid or stony condition, it is found

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in most instances, that the columns arrange themselves at right angles to the cooling surfaces. Thus, in bedded basalt, the columns are vertical, or nearly so, as in the Giant's Causeway, Ireland; Staffa, and other localities in the Western Isles; or like those on the Cathkin Hills, and at Craigallion, near Strathblane, in our own neighbourhood. In these cases it is evident that the cooling has acted from above downwards, the columns being most perfect in form nearest the surface of the bed. In masses of basalt that have come up through the strata, either in the form of dykes or isolated bosses, the columns are generally arranged in horizontal series in the dykes, and in the bosses in a prismatic or radiating order, varying from the perpendicular to the horizontal. Good examples of this latter arrangement are to be seen in the north-eastern face of Dunglass Hill, near the spout of Ballagan, and at the "Spindle Rock," near St. Andrews.

Columnar structure in certain igneous rocks has generally been ascribed to a contraction of the mass in cooling, so that it may be looked upon as a sort of crystallisation on a large and rude scale; the cooling surfaces being determined by the character of the rock mass, and the conditions under which it has been ejected.

Columnar structure in sedimentary rocks is a very much rarer phenomenon than in those of igneous origin; and I have not observed in any of the geological text-books, or other papers that have come under my notice, any special reference to it in this class of rocks. I think, however, there can be little doubt that it has been superinduced by heat acting on the strata in which it is observed.

In most cases we can trace the agent that has produced it. Where intrusive and overlying trap is found in connection with sedimentary strata, it is no uncommon circumstance to find that the strata have been strongly acted upon by the heat; and in several instances columnar structure has been superinduced to a certain extent. In the pits at Shettleston, where an intrusive bed of greenstone lies over one of the coal seams of that locality, the coal is found in parts to be rendered beautifully columnar on a small scale. Columnar coal, or rather coke, has also been found in connection with trap in many other localities in both the Lanarkshire and Ayrshire coal-fields.

We have noticed that the columnar structure in the sedi-

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mentary rocks is always arranged at nearly right angles to the face of the trap. Thus, when the trap is horizontal, the columns are vertical, and when the trap is vertical, the columns are horizontal. A very fine example of this latter feature is to be observed at Bishopbriggs, north of Glasgow, where in a section well-known to many of the members of this Society, a mass of Carboniferous sandstone, several feet in width, is to be seen, locked between the walls of a double dyke of trap that runs from north-east to south-west through the strata, and a horizontal columnar structure has been superinduced in the sandstone at right angles to the vertical walls of the two dykes.

It has also been observed that the sandstone pavement forming the bottom of iron furnaces which have been long in blast, is often rendered columnar, the columns, like those in the red sandstone at Kilchattan, being vertical to the bedding of the stone.

At a short distance along the shore southwards from the section just described, there occurs the finest specimen of a perched boulder I have seen, shewing the effect of the weather and tide on the soft red sandstone. As from its exposed situation on that stormy shore, this boulder cannot remain in its perched position much longer, I have thought it worthy of recording, and also of having it figured in our *Transactions*, from a sketch, with dimensions, taken on the spot by Mr. Dairon.

The upper part or table is a micaceous schist, and the pedestal or pillar is a bedded red sandstone, which is so very soft that it

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can be rubbed away with the fingers. The table has at one time been larger, a considerable corner having split off, and is now lying at its base.

The present dimensions of the table are twelve feet long, seven feet broad, and five feet thick. The pillar is two feet in diameter, and the top of the table is eight feet above the level of the shore at this place.

Perched blocks of stone, supported on a pivot or pillar of ice, are a common phenomenon on many of the glaciers in Switzerland. These blocks are often of large dimensions, and their elevated position is caused by the sun melting away the surrounding ice, while the stone forms a shade like an umbrella to protect its own pillar.

It is evident that in this instance at Kilchattan, the soft column of sandstone owes its preservation in a similar manner to the protecting influence of the mass of rock that now lies above it.*

II.—On a Magnetic Sand from East Bay, Rothesay.

[Read 30th Oct., 1873.]

The magnetic sand now submitted to consideration is from the shore at East Bay, Rothesay. Although previously observed on this part of the coast, no evidence had been obtained with regard to the rocks from whence it had been derived. On examination of the rocks along the beach, I was led to investigate some of the neighbouring trap dykes which cut through the red sandstone, and found that by pounding to a powder portions of the rock of which they are composed—a dark coarse-grained dolerite—I could readily obtain by the magnet small quantities of the magnetic sand. I also found that all the dust

* Sir Charles Lyell mentions some very remarkable perched boulders, which he names "earth pyramids," or "stone-capped pillars," at Botzen, in the Tyrol. He says—

"The columns are of indurated mud, varying in height from twenty to one hundred feet, and are usually capped by a single stone, some of which are ten feet in diameter. They have been separated by rain from the terrace of which they once formed a part, and now stand at various levels on the steep slopes bounding narrow valleys."—*Principles of Geology*, vol. i., pages 335 and 340.

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on the road, which is macadamised with the same trap rock for several miles along the shore, yielded similar sand when tested with the magnet.

Magnetite is one of the most generally diffused iron ores, and none is superior for the manufacture of iron. It is easily distinguished by its being readily attracted by the magnet, and also by the black colour of its streak or powder.

It consists of 69 per cent. of peroxide and 31 per cent. of protoxide of iron, and it occurs largely in the igneous and and metamorphic rocks, either in distinct octahedral crystals disseminated through the mass, or more frequently in compact beds, which in Norway, Sweden, and Russia form a most important iron ore. It rarely occurs in veins.

In Rothesay Bay it is washed up by the tide, and is generally found about high-water mark, where it is easily distinguished by its black appearance on the shore. Being so much heavier than the ordinary sand, when it becomes dry the wind blows away the lighter particles, and leaves the magnetite comparatively pure. Only about 9 to 10 per cent. is attracted by the magnet. The remainder, from its colour and appearance, is possibly ilmanite, which is a titaniferous iron sand, and is much valued for the manufacture of steel.

The magnetite in the Rothesay trap occurs in the form of minute crystals, varying in size from the finest sand up to the tenth of an inch in diameter. The crystals are seen to be more or less water-worn, from rolling on the beach.

Amongst the magnetic sand (about half-tide mark downwards) I found cubes of iron pyrites, varying from three-eighths of an inch downwards. These have evidently been derived from the wearing down of the slate rocks on the opposite side of the bay.

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PROCEEDINGS FOR THE YEAR 1873–74.

ANNUAL GENERAL MEETING, OCTOBER 30, 1873.

MR. EDWARD A. WÜNSCH, *Vice-President*, in the Chair.

ANNUAL REPORT BY THE COUNCIL.

Mr. D. BELL, Secretary, read the Report for the past year, of which the following is a summary:—

MEMBERSHIP.—The number of ordinary members on the roll is 174, shewing an increase of 18 over the previous year, and attaining to a full average number, which has only been exceeded once or twice during the history of the Society. The Council at the same time observe that the number of vacancies caused annually by removal or otherwise seems to be increasing, and trust the friends of the Society will endeavour to secure a corresponding increase in the number of new members annually added to the roll.

ORDINARY MEETINGS.—These have been well attended, and the papers read have, as formerly, been chiefly devoted to the geology of the neighbourhood of Glasgow and other parts of the West of Scotland.

In the EXHIBITION OF SPECIMENS, while the older members shew no falling off, it has been gratifying to notice the zeal and assiduity of some of the younger members.

The ELEMENTARY LECTURES were discontinued, owing to a full and excellent course on Geology being delivered by Dr. Robert Brown of Edinburgh to the Mechanics' Institution.

EXCURSIONS.—The localities visited during the summer were, Thornton Quarries, East Kilbride; Loch Thom and Inverkip; Luss, Beith, Bowling, and Ballagan Glen. A series of shorter excursions in the neighbourhood of the city also took place during the Session.

LIBRARY.—The Library continues to be largely availed of by the members, and the thanks of the Society are due to Mr. Richard Neilson for his care and attention in discharging the duties of Librarian. For some valuable donations of books during the past year, the Society are indebted to Professors Ramsay, De Koninck, and Hull; and the *Transactions* of other Societies, European and American, which are regularly received, form a most useful and important department for the reference of the members.

TRANSACTIONS.—The second part of Vol. IV. was issued early in the year, and more recently the first part of the *Palæontological Series*, which was projected several years ago. This part is devoted to the Silurian Brachiopoda of the Pentland Hills, figured and described by the skilful hand of Mr. Thomas Davidson, F.G.S., Brighton, to whom, as well as to Professor Young and Mr. Armstrong, for their care in superintending the publication of the *fasciculus*, the warmest thanks of the Society are due.

The Council are also gratified to announce that Professor Geikie has kindly consented to place at the disposal of the Society, for republication as

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part of the *Transactions*, a new and revised edition of his valuable "Memoir on the Glacial Drift of Scotland" (originally published in Vol. I., Part 2, of the Society's *Transactions*).

The late Mr. J. WALLACE YOUNG.—The Council record, with much regret, the death, during the past year, at an early age, of Mr. J. Wallace Young, for several years a member of the Society and a contributor to its *Transactions*. Mr. Wallace Young's knowledge of chemistry enabled him to do good service in investigating the composition of rocks; and the results which he arrived at with regard to several of the limestones and sandstones around Glasgow, as set forth in his papers to the Society, are interesting and valuable. One of the pleasantest and most genial of companions, his modest and unassuming demeanour endeared him to the hearts of many, and his early decease causes a loss to the Society which will not easily be made up.

The Council bespeak the zealous co-operation of the members in carrying on the work of the Society, and maintaining or increasing its usefulness.

Mr. WIGHT, C.A., Treasurer, read an Abstract of the Accounts for the year (see p. 172), and the Report was unanimously adopted.

The following donations to the Library were laid on the table:—

"The Quarterly Journal of the Geological Society;" "Transactions of the Edinburgh Geological Society;" "Journal of the Royal Geological Society of Ireland;" "Proceedings of the Royal Academy of Sciences," Vienna; also, from Professor de Koninck, of Liege, a further instalment of his valuable work, "Recherches sur les Animaux Fossiles;" and from Mr. G. S. Brady, C.M.Z.S., and Mr. David Robertson, F.G.S., the newly-published part of their "Contributions to the Study of the Entomostraca."

Mr. THOS. NAISMITH exhibited a beautiful series of Polyzoa, which he had collected from the lower carboniferous limestone at Corrieburn, on the Campsie Fells.

Mr. JOHN YOUNG, V.P., gave some notes descriptive of the specimens, and of the locality where they had been found. He stated that remains of Polyzoa are abundantly distributed throughout certain portions of the strata at Corrieburn; but it is only in a few places, where the rock has become weathered near the surface, that these organisms, with their lace-like and feathery fronds, could be obtained in a distinct and well-marked condition. Sixteen species had already been identified from this locality—the most abundant being *Fenestella* and *Glauconome;* the rarest, *Ptylopora pluma*, which as yet had only been recorded from this place in Scotland. On a recent visit of some of the members to the district, another rare species, *Vincularia dichotoma* (M'Coy.), had been found. Mr. Young then described at some length the structure of one of the species, *Fenestella*, and pointed out some of the differences between marine and fresh-water Polyzoa. He remarked on the beautiful state of preservation of the specimens under notice, and moved the thanks of the meeting to Mr. Naismith for his kindness in bringing them forward.

Mr. JAS. THOMSON, F.G.S., V.P., after a few illustrative remarks, seconded the motion, which was cordially agreed to.

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Mr. D. C. GLEN, C.E., submitted specimens of magnetic sand from the Island of Bute, principally in the vicinity of Rothesay Bay. He described this sand as occurring in little wreaths and patches, and occasionally in more considerable quantities along the shore; and pointed out that it had evidently been formed by the decomposition or weathering of some of the trap-dykes which abound on this part of the coast. Portions of these, when broken down, had yielded a sand entirely similar in its properties. Mr. Glen also exhibited specimens of Magnetite from Norway and Sweden, Spain, the United States, and New Zealand.

Mr. J. KIRSOP exhibited a specimen of Stalagmite from the Falls of Niagara, also some species of Fossil Corals from the Valley of the Nith, the structure and affinities of which were explained to the meeting by Mr. Thomson.

13th NOVEMBER, 1873.

Mr. E. A. WÜNSCH, *Vice-President*, in the Chair.

Mr. JAMES GEIKIE, F.G.S., of the Geological Survey of Scotland, was elected a Corresponding Member of the Society, and the following gentlemen were elected resident members—viz., Mr. Daniel Macbeth, Rothesay; Dr. Maddever, Rothesay; and Mr. Alfred Muckle, C.E., Glasgow.

A paper "On the Post-Tertiary Beds—Kyles of Bute," by the Rev. H. W. Crosskey, F.G.S., and David Robertson, F.G.S. (in continuation of the series contributed by the authors to the *Transactions* of the Society), was then read to the Meeting. (See p. 29.)

Mr. JAMES ARMSTRONG read a paper "On the Fossils found in the Carboniferous Limestone Shales of Gare and Westerhouse," illustrated by a series of finely-preserved specimens collected by himself from these localities, situated about three miles to the north-east of Carluke. After describing the shale-heaps turned out long ago during the working of the limestone as forming a favourite hunting-ground to fossil-collectors, he stated that the geological position of the beds is near the top of the upper limestone series in the carboniferous system of the West of Scotland; and their equivalents are—the Robroyston limestone, north of Glasgow; and the limestone of Limekilnburn, near Quarter, in which the mode of preservation of the fossils is the same, and the greater number of them specifically identical. He then referred to the various classes of animal remains found in the shales, as represented by the collection on the table, and pointed out the special features which many of them presented.

The CHAIRMAN exhibited some interesting specimens of the junction of granite and slate from the Island of Arran, and made some remarks on the position of the granite in that island, and on the various theories which had been propounded regarding its origin. He agreed with those who held that granite is a metamorphic rather than originally igneous rock; at the same time, he had no doubt it must have been subjected to great heat, probably at a considerable depth, and been in a partly fluid or pasty condition, when

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it was subsequently brought into contact with the ordinary sedimentary rocks against which it is now found. He described the junctions of the granite and slate in several parts of Arran, pointing out how the granite veins often penetrate the slate to considerable distances, altering the latter more or less along the lines of contact.

Mr. JAMES THOMSON, F.G.S., V.P., followed with some remarks on the subjects which had been brought under the notice of the meeting, and concluded by moving a vote of thanks to the authors of the communications now read, which was cordially agreed to.

11th DECEMBER, 1873.

Mr. EDWARD A. WÜNSCH, *Vice-President*, in the Chair.

Mr. Robt. Stewart, 28 Abbotsford Place, was elected a Resident Member.

A paper was read which had been received from Mr. James Geikie, F.R.S.E., F.G.S., of H.M. Geological Survey of Scotland, "On the Occurrence of Erratics of Higher Levels than the Rock-Masses from which they have been Derived." (See Vol. IV., p. 235.)

A communication was read from Professor Hull, M.A., F.R.S., Director of the Geological Survey of Ireland, also Corresponding Member of the Society, "On the Microscopical Structure of Red Quartz-porphyry from the Old Red Sandstone near Lesmahagow." (See p. 25.)

Mr. D. C. GLEN, C.E., read some "Notes on a Tract of Columnar Sandstone at Kilchattan, in Bute." (See p. 154.) Having described the position of the sandstone referred to, Mr. Glen stated that, there being no trap rock in the immediate vicinity to cause the columnar structure, as in other cases, he was inclined to attribute the structure in this instance to the long-continued action of heated vapour escaping through a vertical fissure in the strata. Mr. Glen also read a note from Mr. John Young, V.P., coinciding with the explanation now submitted to the Society.

15th JANUARY, 1874.

Mr. EDWARD A. WÜNSCH, *Vice-President*, in the Chair.

The following were elected as Resident Members:—Mr. James Lambert Baillie, Ardrossan; Mr. C. Cox, Retford; Mr. John Tuckwell, 282 Buchanan Street; and Mr. James Miller, 13 Robertson Street.

Mr. DAVID SANDEMAN exhibited some specimens of Caradoc and Devonian pebbles from Budleigh-Salterton, Devonshire. These pebbles occur in a well-marked bed, in cliffs of Triassic sandstone, about five miles from Exmouth. They are formed of a compact quartzite, well water-worn and rounded, and many of them contain fossils, generally in the form of casts,

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some of them indistinct, but others sharp and well-defined. Mr. Davidson had pronounced some species of the Brachiopoda to be of Silurian and others of Devonian age. Mr. Sandeman referred to papers on this interesting deposit by Mr. Linford, Mr. Salter, Mr. Vicary, Mr. Pengelly, and others. He further exhibited some specimens of the "Beer Stone" from the same neighbourhood—a white calcareous sandstone of the lower Chalk formation—soft, and easily worked when first quarried, but becoming hard by exposure.

Mr. J. YOUNG, V.P., made some remarks on the specimens exhibited, and also laid on the table a specimen of *Gyrolepis Rankinii*, Ag., a Ganoid fish of the upper Coal measures, presented to the Society by Dr. Grosart, of Salzburg, Shotts.

Mr. R. L. JACK, of H.M. Geological Survey, then read a paper "On a Boulder-Clay, with Broken Shells, in the Lower Valley of the River Endrick, near Lochlomond, and its relation to certain other Glacial Deposits in the same Neighbourhood." (See p. 5.)

Mr. JOHN YOUNG, V.P., read a paper "On the Occurrence of a Bed of Highly-Indurated Sandstone, with Water-worn Quartzite Pebbles, interstratified with the Trap of the Campsie Fells." (See p. 51.)

12th FEBRUARY, 1874.

ANNUAL BUSINESS MEETING.

Mr. E. A. WÜNSCH, *Vice-President*, in the Chair.

Mr. John Harvie, 27 Union Street, was elected a Resident Member.

The Society appointed Office-bearers for the ensuing year, and the Council was declared to be constituted as under :—

President—Sir WILLIAM THOMSON, LL.D., F.R.S., &c., Professor of Natural Philosophy, Glasgow University.

Vice-Presidents—EDWARD A. WÜNSCH, JOHN YOUNG, JAS. THOMSON, F.G.S.
Joint-Secretaries—DUGALD BELL, 27 Lansdowne Crescent; JOHN BURNS, 352 St. Vincent Street.

Treasurer—JOHN WIGHT, C.A., 150 Hope Street.

Librarian—RICHARD NEILSON, 110 John Street.

Other Members of Council—DAVID SANDEMAN, JAMES DAIRON, DAVID CORSE GLEN, C.E.; DAVID ROBERTSON, F.G.S.; JOHN ORR, ARTHUR PRATT, ARCHIBALD ROBERTSON, DANIEL WILSON, THOMAS NAISMITH, JAMES ARMSTRONG, HUGH M'PHAIL, THOMAS M. BARR.

The PRESIDENT then took the chair, and after thanking the members for his re-election, delivered an interesting address "On the Influences of Geological Change on the Earth's Rotation." (See Vol. IV., p. 311.)

A cordial vote of thanks was awarded to the President for his deeply interesting and instructive address.

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12th MARCH, 1874.

Mr. EDWARD A. WÜNSCH, *Vice-President*, in the Chair.

The CHAIRMAN exhibited a specimen of contorted slate, which had been found by Mr. Hugh Kennedy among the ruins of St. Blane's Chapel, in the south of the Island of Bute.

Mr. YOUNG shewed some beautiful photographs of limestone shale slabs, rich in Encrinites and Polyzoa, taken by Mr. Annan, of Sauchiehall Street.

A paper was then read "On some Polyzoa from the Carboniferous Limestone Shales near Glasgow," by Professor Young, M.D., F.G.S., and Mr. John Young, F.G.S. The authors described two new genera which they had established under the names of *Rhabdomeson* and *Stellipora*.

Mr. ROBERT CRAIG, Langside, Beith, *Corresponding Member*, read a paper "On the Fossils of the Carboniferous Beds around Beith and Dalry, with special reference to the position of their first appearance in the Beds." (See p. 36.)

Mr. JAMES DAIRON read a paper on a new species of Retiolites (*Retiolites fibratus*) found by him last summer in the Moffat shales of the lower Silurian system of the south of Scotland; also a note from Mr. Lapworth remarking on the characteristics of this new form. Mr. Dairon reserved a portion of his remarks till next meeting.

26TH MARCH, 1874.

SIR WILLIAM THOMSON, LL.D., F.R.S., &c., *President*, in the Chair.

An interesting series of rocks and fossils from Canada was exhibited, presented to the Society by Alfred R. Selwyn, Esq., F.G.S., Director of the Geological Survey of Canada, and brought to this country by J. Morgan, Esq., of Montreal. The specimens were described by Mr. John Young, V.P., who stated that the collection embraced typical rocks extending from the Laurentian to the Carboniferous formation, and was of much interest, as enabling members to compare the older rocks of the West of Scotland with those of North America. He reminded the members of the order of succession which had been established by Sir Roderick Murchison in the older Palæozoic rocks of Scotland, viz., that the gneissose rocks of Ross-shire, Sutherlandshire, and the Island of Lewis, are the oldest stratified rocks in Britain, above which the Cambrian and Silurian formations, lower and upper, come in succession. This "fundamental gneiss," as it had been called, seemed to be the equivalent of the "upper Laurentian" rocks of Canada. It had been shewn by the able investigations of the Canadian geologists that these Laurentian rocks in that country constitute a great series, more than 30,000 feet in thickness, and occupying an area of about 200,000 square miles. Also, that they are separated from the Cambrian formation by a great thick-

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ness of quartzite rocks, called the "Huronian series." Their antiquity must therefore be inconceivably great. It was in the lower beds of this most ancient system of rocks that the *Eozoon Canadense*, believed to be a gigantic Foraminifer, the oldest organism yet known to geologists, had been discovered. Specimens of this interesting fossil were included in the collection; also well preserved examples of Brachiopods, Gasteropods, Cephalopods, and other Mollusca, as well as Trilobites and Corals. These were commented on *seriatim* by Mr. Young.

Mr. JAMES THOMSON, V.P., also remarked on some of the fossils, and pointed out the exact correspondence between many of the rock specimens and those which he had collected for years in the Western Highlands, particularly in Lewis and Islay.

Some discussion, in which the President joined, then took place upon the granites in the collection, as to whether they should be considered altered sedimentary strata or true igneous products. The granite veins in the gneiss were, however, held as giving evidence of complete fusion of the rock matter.

The PRESIDENT expressed the pleasure he felt in being present to receive this friendly gift and token of remembrance from their brethren of the Geological Survey of Canada. He remarked that these provinces, which are so closely connected with this country by ties of kindred and family, seemed also to be specially related to Scotland geologically. He pointed out how much the study of science might be advanced by such friendly interchanges between those labouring in different parts of the world; and concluded by conveying the cordial thanks of the Society to Mr. Selwyn and the other officers of the survey for their valuable gift, and also to Mr. Morgan for his kindness in conveying it thither.

Mr. MORGAN briefly replied.

Mr. YOUNG exhibited two large and finely-preserved specimens of *Goniatites Listeri* from the Halifax coal-measures, and made some remarks on the nature of the chambers in the various genera of Cephalopoda, pointing out the gradual complication of the lobed sutures from the simple type, as observed in the *Nautilus* and *Orthoceras* of the Palæozoic period to the lobed and foliaceous sutures of the Ammonites of the Secondary Rocks.

Mr. JAMES DAIRON continued his postponed remarks on the *Graptolites* of the Moffat district, and exhibited a valve of a Brachiopod shell, apparently new to that series of beds, which somewhat resembles *Orthis* or *Strophomena* in form, but is probably an undescribed species. Mr. Dairon illustrated his observations by some beautiful drawings on an enlarged scale of the fossils described.

Thanks were voted to Mr. Young and Mr. Dairon for their contributions, and the Society adjourned till 16th April.

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16TH APRIL, 1874.

MR. E. A. WÜNSCH, *Vice-President*, in the Chair.

The following were elected resident members:—Messrs. J. Renwick, Alexander Munro, Daniel M'Dougall, James White, John Crambton, jun., James Gray, Thomas King, Alfred W. Brown, John Stewart.

Dr. ROBERT BROWN, F.L.S., F.R.G.S., Ex-President of the Royal Physical Society of Edinburgh, read a paper "On the Noursoak Peninsula and Disco Island, North Greenland." (See p. 55.) The paper was illustrated by maps and sections, and some interesting specimens of the rocks and fossils referred to.

Mr. JAMES THOMSON, F.G.S., and Mr. JOHN YOUNG, V.P., having made a few remarks,

The CHAIRMAN conveyed the cordial thanks of the meeting to Dr. Brown for his interesting and instructive paper.

Mr. W. R. W. SMITH exhibited a quantity of magnetic iron sand, collected from the northern shore of Loch Tay, near the outfall of a little stream that descends from Ben Lawers. Mr. Smith also read an analysis of the sand, shewing that fully 27 per cent. of it consisted of peroxide and protoxide of iron, and stated that it might be collected in considerable quantities at the part of Loch Tay referred to, and had long been used by the natives of the district for sharpening their scythes, &c. Its origin seemed to be in the rocks of the Ben Lawers range, from whence it had been worn out by the mountain torrents, and carried down to the shores of the loch.

Mr. T. NAISMITH shewed some finely-preserved heads of Crinoids from the carboniferous limestones of the Beith district.

Mr. J. YOUNG, V.P., submitted some beautiful photographs of limestone shale, containing Polyzoa, executed by Mr. Annan, of Sauchiehall Street, similar to those shewn at a former meeting, but on an enlarged scale.

DISTRIBUTION OF MOLLUSCA, &C.

Mr. DAVID ROBERTSON, F.G.S., then read a paper "On the Recent Ostracoda and Foraminifera of the Firth of Clyde, with some Notes on the Distribution of the Mollusca" (see p. 112).

The CHAIRMAN, in the name of the meeting, thanked Mr. Robertson for his very careful and suggestive paper; and, after intimating that the members would receive notices of the Summer Excursions, the Society adjourned till October.

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SUMMER EXCURSIONS—1874.

		Conductor.
May 2	—High Blantyre, ...	Mr. D. Corse Glen, C.E.
,, 9	—Giffnock, ...	Mr. Dewar.
,, 16	—Corrieburn, ...	Mr. J. Young, F.G.S.
,, 21	—(Queen's Birthday.) Killearn and Blane Valley, ...	Mr. J. Young, F.G.S.
,, 23	—Beith and Dalry, ...	Mr. R. Craig.
June 6	—Craigenglen, ...	Mr. Dairon.

The first of the Annual Summer Excursions of this Society took place on Saturday, 2nd May, 1874, to the district around High Blantyre, lying S. W. from Hamilton—Mr. D. C. Glen, C.E., conductor. The day being fine there was a large turn-out of members. Mr. Glen explained the sections of geological interest along the route. On arriving at High Blantyre the party proceeded southwards to the Newfield and Broomhouse limestone quarries, examining on the way the section of boulder-clay and sandstone strata at present exposed on the line of railway near the station. At this point the nature and extent of the great Eddlewood fault was explained to the members. This fault throws down the upper red sandstone and higher coal measures of the Blantyre district to the north to the same surface level of country with that of the marine limestone strata of the Blantyre district to the south, the displacement being upwards of 2000 feet. Great, however, as has been the disturbance of the earth's crust along this tract of country, there are few evidences of this existing fault now to be seen in the present features of the landscape, all the irregularities having been planed down by subsequent denudation. The knowledge and position of the course of the fault has in most cases been obtained during the working of the various economic strata which lie on each of its sides. At one of the clayband ironstone pits on Blantyre Muir a few fragmentary remains of plants and fishes were found; and from the richly fossiliferous shales of the limestone at Newfield Quarry and the adjoining pits, numerous fine specimens of various species of Fenestella and other Polyzoans were obtained, as were also several fine Brachiopod shells, Corals, Crinoids, and Trilobites. The locality has yielded many rare fossils to members of this Society in past years, and the result of this visit shews that it is not exhausted. The party returned to Glasgow heavily laden, and highly delighted with the day's proceedings.

The second excursion of this Society for the season took place on Saturday 9th May, 1874, to Giffnock, to view the carboniferous sandstone, cement limestone, and shale for which the district is remarkable. Mr. Dewar obligingly acted as conductor. On arriving at Giffnock Station the party at once proceeded to the extensive quarries wrought for so many years by the Messrs. Stevenson, who very kindly had retained a number of the hands to give any

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assistance necessary. The managers, Messrs. Low, it is right to say here, were also in attendance, and in a courteous manner conducted the party through the workings, which, the general reader will note, are underground, and to some extent intricate, from their extent and the darkness which pervades them. The Giffnock quarries are unique in their way, affording a field of study for the practical geologist. They consist of vast tunnellings underground. The arches, formed in the course of years by the removal of the sandrock, are 40 feet high or more in many places, and the mine resembles in outline the interior of so many cathedrals. The walls, right and left, go straight to the roof; the roofs take a hemispherical form, and, though rough to a degree, send forth an echo. Altogether, the workings are very wonderful and full of interest. The mine requires to be lighted up while the men are working. This is done by means of large naphtha lamps, which on this occasion were carried in the hand by the men in attendance. This sandstone, extensively used, is well known for its white colour, its lasting quality, and its absence of stratification, from which latter circumstance it has been denominated the "liver rock." It is on that account capable of being cut with freedom in any direction when being taken from its native bed or hewn for building. This sandstone lies at the base of the upper carboniferous limestone series overlying the Possil group of coal and limestone to the north and west of Glasgow. The equivalent to the sandstone on the north of the Clyde is Kenmuir and Bishopbriggs sandstones, which have also been largely wrought for building purposes. The position of this group of sandstones lies upwards of 400 fathoms under the red sandstones of the Bothwell and Blantyre district visited by the Society on its former excursion; and the distance of this sandstone to the underlying Campsie and Hurlet strata will be upwards of 300 fathoms. It therefore occupies a middle position in the carboniferous basin. The thickness of the carboniferous strata in the Glasgow coalfield is nearly 800 fathoms. Mr. Young and Mr. Dewar further explained the position and characteristic features of this sandstone; after which the party next proceeded to Mr. Dewar's Orchard Cement Works, which are contiguous to it. The limestone wrought here lies over the sandstone—the strata dipping to the south and east. The band of limestone is from 20 to 24 inches thick and of excellent quality, and has been long worked as a cement. Underlying this limestone is a thin seam of coal, from two to three inches thick, which is used for calcining the limestone—which is then ground into a powder before being sent to the market. The shale overlying the limestone contains an interesting group of fossils, many of which are in an excellent state of preservation. The principal fossils which have been found are *Productus costatus*, *Spirifera lineata*, *Actinoceras giganteum*, *Leda attenuata*, *Orthoceras subcentrale*, with other Univalves and Bivalves, Foraminifera, &c. The members applied themselves to the search for fossils with great energy; and having employed themselves very pleasantly in this way for upwards of an hour, they proceeded to examine an interesting group of flagstones, which is worked in the quarry to the westward of Giffnock, and which lie under the position of the sandstone first visited. The flagstones are from three to twelve inches in thickness, and are separated at almost regular intervals by a thin layer of dark-blue

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sandy shale, which causes the beds of sandstone in the face of the quarry to have almost an artificial appearance, from the way the strata are built up layer above layer. On examining the various layers of flagstone, it is found that the upper surface has been penetrated vertically to the depth of from two to three inches by the burrows of Annelids. So numerous are these burrows on the surface of the beds that they produce a horny crust or riddle-like appearance. On some of the flagstones the traces and ejectamenta of other marine worms are left in high relief, presenting an appearance similar to that which is to be found on the sands of our shores at the present time. The burrows are filled up with dark-blue shale. Mr. Dewar and Mr. Young (V.P.) explained the position and nature of the beds, and a hearty vote of thanks was accorded them for the graphic and interesting description given of the various localities.

The third of the Annual Field Excursions of this Society took place on Saturday, 16th May, 1874, the district visited being Corrieburn, on the Campsie Fells—Mr. John Young, V.P., conductor. Between thirty and forty, including a few of the more experienced members, assembled at Dundas Street Station, and proceeded by the 1.45 P.M. train to Kirkintilloch. On arriving there, the party proceeded along the Valley of the Kelvin by the Inchbelly Road. After a pleasant walk of four miles, the party arrived at their destination, and at once proceeded to examine the various phenomena of this interesting locality. Corrie lies on the hillside to the north-east of Kirkintilloch, being, as already stated, four miles from that place, and fully two miles north-west of the town of Kilsyth. The principal sections of strata occur at an elevation of from 800 to 900 feet above the sea level, the hills in the background rising to a height of 1500 feet. The very fine view which is obtained of the great coalfield of Lanarkshire to the south, as well as of the more distant tract of hill country which lies beyond, extending from the Pentlands in the south-east to the Arran hills in the south-west, which, taken along with the other varied geological phenomena of this portion of the Campsie range, have long made Corrieburn one of the best teaching grounds in physical geology around Glasgow. The party proceeded by the western burn of the Corrie to examine the beds of volcanic ash and other igneous products, which are there interstratified with the sandstone, ironstone, and shales that underlie the limestone series, the action of the heat derived from contact with the volcanic group being very observable in the highly indurated condition of the sedimentary strata at various points. They next examined the boulder clay, with its numerous glaciated erratics, lying near the head of the western burn, some of these being of huge size—the till at this point forming the deeply coomed bank to the west, while its eastern bank is composed of a lofty wall of trap, over which the mountain stream tumbles in a cascade, which, by its action, has scooped out the deep gorge between the abutting till on the one hand and the trap on the other. The next place visited was the eastern burn of the Corrie, some of the members examining on the way and obtaining specimens from the vein of sulphate of barytes that passes through the trap at this place. The section in the eastern burn is composed

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of shale, with numerous bands of clay ironstone nodules, the whole presenting a beautiful system of stratification. A search for the fossils found in the beds was here commenced, several fine specimens of *Orthoceras undatum* and *O. cylindraceum* being obtained, as well as one or two examples of *Goniatites*, one of which—*G. sphæricus*—measuring nearly three inches in diameter, is the largest yet recorded from the Corrie beds. A short search was also made amongst the Polyzoan shales that lie over the main limestone of the Corrie section. Numerous examples of these beautiful lace-like organisms were obtained, the rarest of which being *Ptylopora pluma* and *Fenestella multiporata*. Specimens of the commoner fossils of the coralline limestone series were also found; these need not, however, be specially mentioned here, as they, along with the other organisms of the Corrie strata, are already recorded in the Society's *Transactions*. Mr. Young gave an explanation of the various geological phenomena observed in the sections at Corrie, and pointed out the relation of the strata to that of other portions of the Scottish coalfields. He also referred to the rich fields of ironstone belonging to the Possil and Govan series that remained yet to be opened up along the valley of the Kelvin between Glasgow and Kilsyth, but which has now been commenced at various points, the working of which will be very much facilitated when the proposed Kelvin Valley Railway is completed. Mr. James Thomson, F.G.S., one of the vice-presidents of the Society, also gave interesting information regarding the fossils obtained, and pointed out the nature of the various rocks as the party went along. After spending a very pleasant afternoon upon the hillside, the members proceeded in the evening to Kirkintilloch, in time for the last train to Glasgow, all being highly delighted with the excursion.

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ABSTRACT of the ACCOUNTS of the GEOLOGICAL SOCIETY of GLASGOW,

For Year Ending 30th September, 1873.

REVENUE.

RECEIPTS.

Subscriptions—						
Arrears for 1871-72, 4 at 10s.,	£2	0	0			
Subscriptions for current year, 160 at 10s.,	80	0	0			
New Members' Subscriptions, 13 at 10s.,	6	10	0			
				£88	10	0
Petty Receipts,				1	7	8
Sale of *Transactions*,				4	16	6
Surplus from Conversazione,				13	13	3
Drawn from Bank,				37	0	4
				£145	7	9

DISBURSEMENTS.

Balance due Treasurer,	£0	16	2½
Printing *Transactions*,	33	6	9
Bookbinding, Drawings, and Engravings,	11	11	8
Rent, Taxes, Insurance, &c.,	13	1	0
Postages, Parcels, Advertising, and Reporting,	12	17	11
Printing Cards, Circulars, &c.,	9	6	9
Miscellaneous Disbursements,	6	2	6
Lodged in Bank,	46	4	8
On hand,	12	0	3½
	£145	7	9

STOCK.

Liabilities current,	£40	0	0	Cash in Bank on Deposit Receipt,	£30	0	4		
Balance, net Stock,	191	7	8½	,, ,, on Current Account,	14	7	1		
								£44	7 5
				,, on hand, as above,				12	0 3½
				Publications, Fossils, and Casts,				175	0 0
	£231	7	8½					£231	7 8½

GLASGOW, *29th October*, 1873.—We have examined the Accounts, of which the above is an Abstract, and find the same correct.

(Signed) JAMES MACAULAY.
THOS. M. BARR.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. V.—PART II.

GLASGOW: PUBLISHED BY THE SOCIETY
AT THEIR ROOMS IN ANDERSON'S COLLEGE BUILDINGS.
1877.

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The Editor begs to state that the Authors are alone responsible for the facts and opinions contained in their respective papers.

ARCH. K. MURRAY AND CO., PRINTERS, GLASGOW.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

VIII.—Note *on the* Polyzoa *of the* Hairmyres *Limestone Shale*, East Kilbride. By John Young, V.P., F.G.S., and David Robertson, F.L.S., F.G.S.

[Read 12th Nov., 1874.]

Amongst the numerous localities where the Carboniferous limestone strata of the West of Scotland have yielded the remains of Polyzoa, we know of none where these organisms have been obtained in greater profusion and variety, than at Hairmyres, near the village of East Kilbride, Lanarkshire. At this place, in former years, a bed of limestone, of the calmy or cement variety, in which comparatively few fossils are found, was worked along its outcrop in open-cast quarries, but in recent years these quarries have been abandoned, although plenty of the limestone is still to be found at a moderate depth from the surface. The Rev. David Ure has the following note on the Hairmyres limestone*: "Lime from Kilbride is in high repute, both for manure and building. It generally takes a strong band, and some of it, especially that from Hairmyres, has this peculiar quality, that, when properly mixed and wrought, warm as the workmen express themselves, it very readily takes a firm band in water. For this reason it is used in building bridges." Ure further mentions that this lime, if used for plaster work before being properly soured or slacked, "has a tendency to rise in blisters, and has been found to lose its hardness and consistency, and to fall down into powder, after being for sometime on the wall. A considerable quantity of moisture seems necessary to

* "History of Rutherglen and East Kilbride," Glasgow, 1793, p. 260-1.

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make this uncommon lime retain its solidity. Owing to this quality, however, it may in some cases be preferable to most other kinds of lime. Its peculiarities are probably owing to a considerable quantity of selenite (*sulphate of lime*) and manganese that appear to be in the stone." The manganese here spoken of is probably a misprint for magnesia (or carbonate of magnesia), which is present to a slight extent in our Carboniferous dolomitic limestones.

This stratum, which varies in thickness from 3 to 4 feet, lies in the lower limestone group, and is believed to be the equivalent of the Birkfield or first calmy limestone of the Carluke district.* As formerly stated, the limestone itself is not rich in fossils, but the shale that immediately lies over the limestone is almost exclusively made up of the remains of organisms, of which Polyzoa and Crinoidea are the most abundant. This shale forms what is termed the lid of the limestone, and splits into large slabs, on the weathered surfaces of which there are to be seen numerous fragments of fronds of *Fenestella*, *Polypora*, and *Glauconome*, in a more or less perfect state of preservation, while the debris of these and other genera of Polyzoa completely cover the surface of the stone. At one time any quantity of these limestone slabs, covered with their organisms, might have been collected near the old quarries, but, what with the farmer using them for covering drains, and the visits of geologists to the locality, few good specimens are now to be obtained. We are indebted to Mr James Bennie, of the Geological Survey of Scotland, for the discovery of a spot near Hairmyres Railway station, where this bed of rich Polyzoa shale is to be found in a soft weathered condition; in which state, after being dried, and washed clean in water, the debris can be easily searched for the fragments of Polyzoa and the other contained organisms, and which occur in an excellent state of preservation, the Polyzoa being of a fine white colour. The fragments, when mounted, are interesting objects for microscopic investigation, and in this form are better fitted for examination than those found on the slabs, although the latter show the habit of growth of some of the species more clearly. The spot at Hairmyres where the weathered shale can be collected, is in the marsh alongside the line of

* See Explanation to sheet 23 of the Geological Survey of Scotland, p. 69, 70, for list of fossils found on this horizon.

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railway which is bounded by the curling pond. As the water covers the ground during the winter months, it can only be got readily in summer. When washed free of the clay, it is found to be nearly a pure Polyzoa debris, in which are seen the other organisms contained in the bed. The list of Polyzoa is subjoined :—

Actinostoma fenestratum, Dr Young and J. Young.	Common.
Archæopora nexilis, De Koninck.	Rare.
Ceriopora interporosa, Phillips.	Rare.
——— *similis*, Phill.	Rather rare.
Diastopora megastoma, M'Coy.	Common.
Fenestella crassa, M'Coy.	Rare.
——— *carinata*, M'Coy.	Rare.
——— *formosa*, M'Coy.	Rare.
——— *membranacea*, Phill.	Common.
——— *nodulosa*, Phill.	Rather rare.
——— *plebeia*, M'Coy.	Common.
——— *tennuifila*, Phill.	Rare.
——— *undulata*, Phill.	Rare.
Glauconome stellipora, Y. & Y.	Common.
——— *aspera*, Y. & Y.	Rare.
——— *elegans*, Y. & Y.	Common.
——— *flexicarinata*, Y. & Y.	Rare.
——— *laxa*, Y. & Y.	Rare.
——— *marginalis*, Y. & Y.	Very common.
——— *retroflexa*, Y. & Y.	Very common.
——— ——— ———	Rare.
Hyphasmopora Buskii, Etheridge.	Rare.
Rhabdomeson gracile, Phill.	Common.
——— *rhombiferum*, Phill.	Rare.
Polypora tuberculata, Prout.	Very common.
Synocladia carbonaria, Ether.	Very rare.
Sulcoretipora parallela. Phill.	Common.

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IX.—Notes *on the* Silurian Rocks *of* Dumfriesshire *and their* Fossil remains. By James Dairon, V.P.

[Read 10th December, 1874, and 20th April, 1876.]

Underneath the finely rounded, green clad surface of the hills of Upper Annandale, in the south of Scotland, we find a vast series of thick-bedded rock called Silurian grit, and formerly known as Grauwacke. This grit is hard and compact, of a greenish grey, and sometimes of a purplish tint. Accompanying it there is also to be found a dark-coloured slaty shale, and these two series form the Scottish equivalents of the Upper Llandeilo beds.

In examining the black Graptolitic mudstones or shales of the Moffat district, say at Dobs Linn, Hartfell, Beld Craig, or in many other places, their position and appearance at once show that they must have been subjected to great disturbing influences long after they had been laid down quietly on the old Silurian sea bottom; for we find them tilted up at very high angles, and in many instances quite vertical. They are also very much twisted and contorted, with numerous jointings running at right angles to the line of stratification. And in connection with these jointings occur frequent small faults which spoil many a fine specimen. In their crumpled state it is exceedingly difficult to split them up, while in their normal condition it can be done with the greatest ease.

In section we see these dark shale beds passing along in an undulating or waving form, plunging beneath the reefs of hard grit, and making their appearance again and again in more distant parts. To what agency can be attributed the great force which has been at work displacing, upheaving, and contorting these rocks? There are no trap dykes, or outbursts of igneous rocks observable in the locality, such as are so common in the Western Highlands. I have only seen one spot near Moffat, where the trap rock appears at the surface, and which was shown me by the late Mr Brown of the Star Hotel in that town. Here the trap was quarried for road-making purposes, but is not at present in use.

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The mineral composition of these dark-coloured mudstones or shales, seems to vary very much. In many places they are anthracitic to the extent, it is stated, of 5 per cent; other shales, again, are charged with aluminous pyrites which effloresce after they have been exposed to the air for some time, splitting them up, and gradually reducing them to powder, while another part of the shale beds may be entirely free from that substance, and, as a rule, split up easily, exposing their fossil remains in an excellent state of preservation.

In the Moffat district the Graptolitic shales may safely be divided into two well marked groups: the upper containing the more simple forms, the lower holding the remains of the branching and more complex kinds of Graptolites. I am aware that there are some writers on the Moffat shales who endeavour to make three or four Graptolitic horizons. But I am not disposed, with the evidence before me, to go that length at present, thinking that multiplication of horizons only leads to confusion. Some time ago, when at the Beld Craig, a short distance from the place where beautiful examples of the simple forms are got, I was fortunate in discovering a spot where the lower or branching species, such as *Dicellograptus*, *Pleurograptus*, are found in great abundance, none of these forms having been previously got at Beld Craig. This locality may now be classed with Dobs Linn and Hartfell, as containing the lower shales with their equivalent organisms. I may here mention that this lower shale is very easily broken across the bedding, falling into small tabular pieces, but it hardens when exposed for some time to the atmosphere. A number of years ago a person, acting under unsound advice, and deceived by the bituminous appearance of the shale, began to sink a shaft for coal near this spot, but of course had to abandon it, after spending a great deal of money. Garpel glen, so far as yet known, has yielded none of the complex forms, but in some nook of this lovely spot, it is hoped that further investigation may yet bring to light the lower group of shales and their accompanying fossils.

I have already spoken of the underground influences which have affected the Graptolitic shales to the extent that must necessarily have been at work in upturning them from their normal position. I might further point to how favourably they now lie to be acted upon by atmospheric influences. The rain gets upon their upturned edges, the frost expands and splits them

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up, they fall asunder and form great taluses such as we see in many places, and these in winter are swept down by the flooded streams. I have frequently picked up excellent specimens in the river Annan, at a distance of six or seven miles from the parent rock at Hartfell, and also in Moffat water, showing the great effect of water in the removal of rocks.

In most of the above localities, and in many others at or near the base of the hills, we find large patches of a red sandstone which elsewhere assumes the appearance of a breccia, containing, as it does, a considerable mixture of angular pieces of the older Silurian grits, and other rocks. It is well represented at the foot of Hartfell, and again at Frenchland burn; also, in the bed of Wellburn, where there is also a small patch. At Dobs Linn it has more the appearance of a decomposed sandstone, and is very red in colour. Observing this at so many points, I think we may be justified in supposing the hills around to have been capped with a thick bed of sandstone which was denuded away, and washed into the hollows in the old Silurian valleys below. These red patches have been referred to the Permian series.

The Graptolitidæ, so far as is at present known, are entirely confined to the Silurian rocks, dying out at the close of that formation. Although those ancient Zoophytes have thus not a wide range stratigraphically, yet, geographically it is greater, as they are found in various parts of the globe. And indeed wherever the old Silurian grits are exposed, the Graptolitic black mudstones or shales will generally be found accompanying them. No fossil remains have as yet been got in the grits of Moffatdale, but their equivalents in Cumberland have yielded, I believe, a few species, though in a bad state of preservation. These grits make an excellent building stone, and are extensively used for that purpose. The zoological position of the Graptolitidæ has given scope for various opinions as to their family relationship, many authorities holding that they are allied to the living *Virgularia*, while others refer them to *Sertularia*. The late Mr Salter up to his death thought they should be placed with the Polyzoa, but it is now generally admitted they have their nearest allies in the Sertularian Zoophytes or sea firs. The remains of the Graptolite, as found embedded in the dark-coloured shales, showing a long row of denticles, is nothing more than an outside

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frame-work or skeleton filled in with foreign matter, and there can be no doubt that in its living state it was invested with a chitonous or horny covering, such as forms the chitine envelope of the colonies of Sertularians. The differences between the Sertularian Zoophyte and the Graptolite may be thus summed up—they both consist of a colony of Zooids, each of which inhabits a chitonous cell or "hydrothecæ;" they both have forms of a single row, and also a double one; they have both a common canal. One point of difference, however, is that the Graptolitidæ were supposed to be free floating organisms, while the Sertularians were invariably fixed. Another difference is, that the cells or "hydrothecæ" of the Sertularians are not in contact or overlapping each other, while those of the Graptolitidæ are mostly overlapping, the genus *Rastrites* forming an exception. Another difference still is, that the Sertularians have no stipe or solid axis and common canal, as possessed by the Graptolites.

To determine and name species of this class of organisms would require great caution on the part of a collector, as there are many causes which may alter the appearance of the Graptolitic remains, such as the position in which they lie in the matrix, the degree of pressure they have sustained, and the age of the organisms; these variations in each circumstance may all tend to mislead, and cause new varieties or species to be made out of the same Graptolitic form. In proof of this, we have only to take up one of the specimens that I have brought forward for illustration, viz.: *Diplograptus tamariscus*, Nicholson. The upper part of the organism is in relief in a beautiful state of preservation, while the under part is squeezed or compressed, being the state in which it is generally found. I venture to say, that any one not acquainted with the fossil would certainly be liable to make two distinct species out of it if each portion was found separate from the other.

In order to show the process of development, I have brought forward a slab crowded with the young forms or "germs" of Graptolites, many of them assuming a dagger-like shape, and from one-eighth to one quarter of an inch in length. Lobes or cells begin to grow at a certain distance from the initial point upon the solid axis, increasing in number and size, until they reach the distal termination; but in the genus *Diplograptus* they taper generally to the distal point before the completion of the adult form.

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I will now give brief descriptions of a number of species, from the Moffat district, belonging to the following genera, and of which specimens are before you, viz. :—

Climacograptus.	*Diplograptus.*
Dicellograptus.	*Dicranograptus.*
Graptolites.	*Rastrites.*
Pleurograptus.	*Retiolites.*

By the aid of a model which I have constructed, and which shows the internal and external structure of *Climacograptus teretiusculus*, one of four well-known forms, I hope to be able to describe more plainly than I could by any drawing, the characteristics of several species. *Climacograptus teretiusculus*, His., was described and named by Prof. M'Coy as *Diplograpsus rectangularis*, and of this I bring forward various specimens: one in relief shewing the notches and cell mouths in their original position; another a scalariform example; and several others shewing the cell mouths and partitions. It is very abundant, having a wide range, passing up through the Skiddaw Slates, Lower and Upper Llandeilo, Carradoc, and Lower Llandovery. It will be observed that the frond of this species shows no row of denticles or hydrothecæ, as in *Graptolithus sagittarius*, Linn., *G. Nilssoni*, Barr., and many others, but merely eliptical indentations forming the cell mouths on both sides of a cylindrical frond or tube, which are not level to each other but alternate. Its width when fully developed is about one-eighth of an inch, the solid axis being prolonged both proximally and distally to a considerable length, the external appearance of the frond varying according to the amount of pressure it may have sustained. There are about 30 hydrothecæ to an inch. The cylinder or frond of *Climacograptus teretiusculus*, His., is made up of two semi-circular compartments, placed back to back, the median septum, with the solid axis placed in the centre of it, forming a mutual gable or partition, as it were, between the two colonies of Zooids, which have each their own row of cells and common canal, each colony being thus quite independent of the other. The localities for this species are Dobs Linn and Duffkinnel burn, Hartfell, etc.

In the genus *Dicellograptus* the polypary is composed of two simple branches, springing bi-laterally from the radical or initial point. The branches or arms are monopriodon, and assume different angles in different species. The cells or hydrothecæ are

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generally opposite to the radical or initial point, but in some examples they are found on the same side. The size of the radical or spines varies very much in different species, and in some they are altogether awanting. It seems not easy to determine to what uses those spines could have been applied, as there is no evidence that they were objects of attachment. If we look at their different positions, with regard to the spines inside of the angles, or concave parts rendering these, one would think it impossible that they could be used for the purpose of attachment; besides, as already stated, there are some forms without any radical or initial point whatever.

The genus *Dicellograptus* was founded by M'Coy as *Didymograptus* (1851), and includes those Graptolites which are bifid, or of a twin character. The vertical range of this genus has its commencement in the Skiddaw and Quebec groups, and also attains its maximum in those rocks, in which it is represented by numerous and remarkable examples. It besides occurs in the Lower Llandeilo, and is also well represented in the Upper Llandeilo, but is scarcely known in the Carradoc rocks of this country; several examples are, however, found in the rocks of this age in America. This genus is not known in the Upper Silurian series, and may safely be said to be characteristic of the Lower Silurian period. The localities where I found it in Moffatdale are Dobs Linn and Hartfell.

The polypary of the genus *Dicranograptus*, Hall, has a double row of cells towards the proximal point, but divides at a certain distance up from the radical into two monoprionidian branches, on the outside only; or keeping the same line as commenced at the proximal point, and having two small lateral spines at each side of minute radical. The structure of *Dicranograptus ramosus*, Hall, resembles the form *Diplograpsus* for so far up or at the branching point, but the hydrothecæ appear to have the same form and structure as *Climacograptus*. The branching of the two arms at a certain distance makes it easily distinguishable from the allied forms *Diplograptus* and *Climacograptus*. In its vertical range the genus *Dicranograptus*, so far as at present known, is entirely confined to the Upper Llandeilo of Britain, but is found in the Carradoc rocks of North America. Its localities here are Dobs Linn and Hartfell.

The genus *Monograptus*, or the simple Graptolite, consists of a

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single row of cellules, ranged on one side of a long fibrous rod or solid axis, and which is often prolonged beyond each end. Between the base of the cells and solid axis is a cylindrical space, called the common canal, in which was enclosed a fleshy substance or coenosarc, from which the buds took their form, and is thought to have been thrown off at stated intervals. This common canal is frequently observed running along between the cellules and solid axis; the cells or hydrothecæ receiving their origin from the coenosarc are merely small cups or tubes which each contained one inhabitant. The cells are supposed to have had four borders; the inner is not defined, in consequence of it forming the under part of the cellule which rests on the common canal; the outer border forms the cell mouth. In some forms this margin is very small, as seen in *Monograptus Sedgwickii*, and in some others, and may be said to scarcely exist. The inferior margin bounds the cellule proximally, the superior forming the distal point. Its localities near Moffat are Beld Craig, Garpel burn, and Dobs Linn.

The curious genus *Pleurograptus* is one of the branching forms, the frond being composed of two serrated branches, springing right and left from an initial point or radical process; but sometimes this latter is not present. A second growth of branches breaks off from the main stem or primary branch, and this is repeated on the opposite side of the stem. They are not level to each other, but alternate, growing at nearly right angles to the stem, and other branches growing from them again. One of the many specimens of this genus which I have, shews another branch, especially a specimen from Beld Craig, which gives off branches repeatedly, while the one figured by Mr Carruthers only gives off two from the main stem. *Pleurograptus linearis*, Carr., is the only known species of this genus. I have found it in the Moffat district at Hartfell and Beld Craig.

The genus *Rastrites*, Barrande, is well represented in the Moffat shales. It has a slender solid axis, often fragmentary, curved, and sometimes of a scroll form, upon which the cells are ranged at right angles. The cellules vary in distance from one-eighth to one-sixteenth of an inch, as in the species *R. peregrinus*, Barr., each cell or tube standing quite clear and independent of another, differing from the genus *Monograptus* by the cells which are mostly in a sloping direction, and overlapping each other. Its

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localities in Moffatdale are Garpel burn, Beld Craig, and Dobs Linn.

Time will not at present permit me to describe in detail all the different genera and species before you, but I intend, at some early date, to bring before the Society another collection of Hydrozoa and Crustacea from the Moffat shales, and which may be made the subject of another paper.

Explanation of Plate I.

Fig.		
1.	*Rastrites peregrinus*, Barrande. Natural size.	Beld Craig.
2.	——— *capillaris*, Carruthers. Slightly enlarged.	Beld Craig.
3.	*Monograptus intermedius*, Carr. Natural size.	
4 & 10.	—— *lobiferus*, M'Coy. 4 enlarged, 10 nat. size.	Polmoody Burn.
5.	——— *sagittarius*, Hisinger. Slightly enlarged.	Garpel Burn.
6.	——— *Sedgwickii*, Portlock. Natural size.	Dobs Linn.
7.	——— *Clingani*, Carr. Natural size.	Duffkinnel Burn.
8.	——— *tenuis*, Portl. Slightly enlarged.	Garpel Burn.
9.	——— *Sedgwickii*, Portl. (var. *spinigerus*, Nich.) Natural size.	Polmoody Burn.
11.	——— *Sedgwickii*, Portl. (var. *triangulatus*, Harkness). Natural size.	Polmoody Burn.
12.	——— *fimbriatus*, Nich. Natural size.	Polmoody Burn.
13.	——— *Halli*, Barr. Natural size.	Polmoody Burn.
14.	*Diplograptus palmeus*, Barr. Natural size.	Polmoody Burn.
15.	——— *folium*, Hisinger. Natural size.	Garpel Burn.
16.	——— *cometa*, Geinitz. 16A enlarged.	Beld Craig.
17 & 18.	——— *angustifolius*, Hall. 18 nat size, 17 enlarged.	Polmoody Burn.
19 & 27.	*Climacograptus teretiusculus*, His. Both enlarged.	Dobs Linn.
20.	*Diplograptus vesiculosus*, Nich. Natural size.	Dobs Linn.
21.	*Climacograptus Wilsoni*, Lapworth. Natural size.	Dobs Linn.
22.	——— *pristis*, His. Natural size.	Dobs Linn.
23.	——— *acuminatus*, Nich. Twice enlarged.	Polmoody Burn.
24.	——— *Whitfieldii*, Hall. Twice enlarged.	Dobs Linn.
25.	*Climacograptus bicornis*, Hall. Slightly enlarged.	Dobs Linn.
26.	*Glossograptus Hincksii*, Hopkinson.	Hartfell.

Explanation of Plate II.

Fig.		
*1.	*Thamnograptus crucifer*, Dairon. Natural size.	Hartfell.
2.	*Dicellograptus anceps*, Nich. Natural size.	Dobs Linn.
3.	*Dicranograptus ramosus*, Hall. Natural size.	Hartfell.
*4.	*Retiolites branchiatus*, Dairon. Enlarged half.	Dobs Linn.
5.	*Amphigraptus divergens*, Hall. Natural size.	Beld Craig.
6.	*Dicranograptus sextans*, Hall. Natural size.	Hartfell.
7.	——— *Nicholsoni*, Hopk. Natural size.	Dobs Linn.

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Fig.		
8.	*Dicellograptus divaricatus*, Hall. Natural size.	Dobs [illegible]
9.	——————— *elegans*, Carr. 9A enlarged.	Dobs Linn.
10.	*Amphigraptus divergens*, Hall. Natural size.	Hartfell.
11.	——————————— shewing a bud from main stem.	Hartfell.
12.	*Leptograptus flaccidus*, Hall.	Dobs Linn.
13.	*Corynoides calicularis*, Nich. Enlarged twice.	Hartfell.
14.	*Lasiograptus costatus*, Lapw.	Dobs Linn.
*15.	*Dicellograptus guilloche*, Dairon.	Dobs Linn.
16.	——————— *divaricatus*, Hall. Shews radical, with spines.	Dobs Linn.
17.	*Pleurograptus linearis*, Carr.	Hartfell.
18.	*Lasiograptus margaritatus*, Lapw.	Dobs Linn.
19.	*Diplograptus quadrimucronatus*, Hall.	Hartfell.
20.	*Leptograptus flaccidus*, Hall.	Hartfell.
21 to 26.	Germs of various species twice enlarged.	Dobs Linn.

The figures are drawn from specimens in my own collection. The nomenclature is taken from Mr Lapworth's list in the Catalogue of Western Scottish Fossils, Glasgow, 1876. I adopt it for the sake of uniformity, although I do not agree with it in all cases.

* Figures 1, 14, and 15 of Plate II. will be described in a future paper.—J. D.

X.—Notes *on a Tract of* Vertical Trees *in* Carboniferous Strata. By William Grossart, Surgeon, Salsburgh.

[Read 11th March, 1875.]

The finding of fossil trees in an erect position is not a new fact. The mere fact of their occurrence, however, gives us no information as to the *modus operandi* that placed them in position, whether they grew on the spot we now find them, or were drifted by currents, deposited in soft mud, finally sunk, and by some unknown physical law raised to an erect position. No efforts ought to be spared, when opportunity offers, of noting carefully the condition and arrangement of the accompanying stratification, as it is not to the tree-trunks alone, but to their surroundings, that we must turn for information on this very interesting period in the earth's history. To further this object is the aim of the following brief communication.

The lower Drumgray coal is wrought at eight different points in the west end of Shotts parish, at an average thickness of twenty-two inches; the normal arrangement of the strata immediately above the coal being nearly uniform throughout. It

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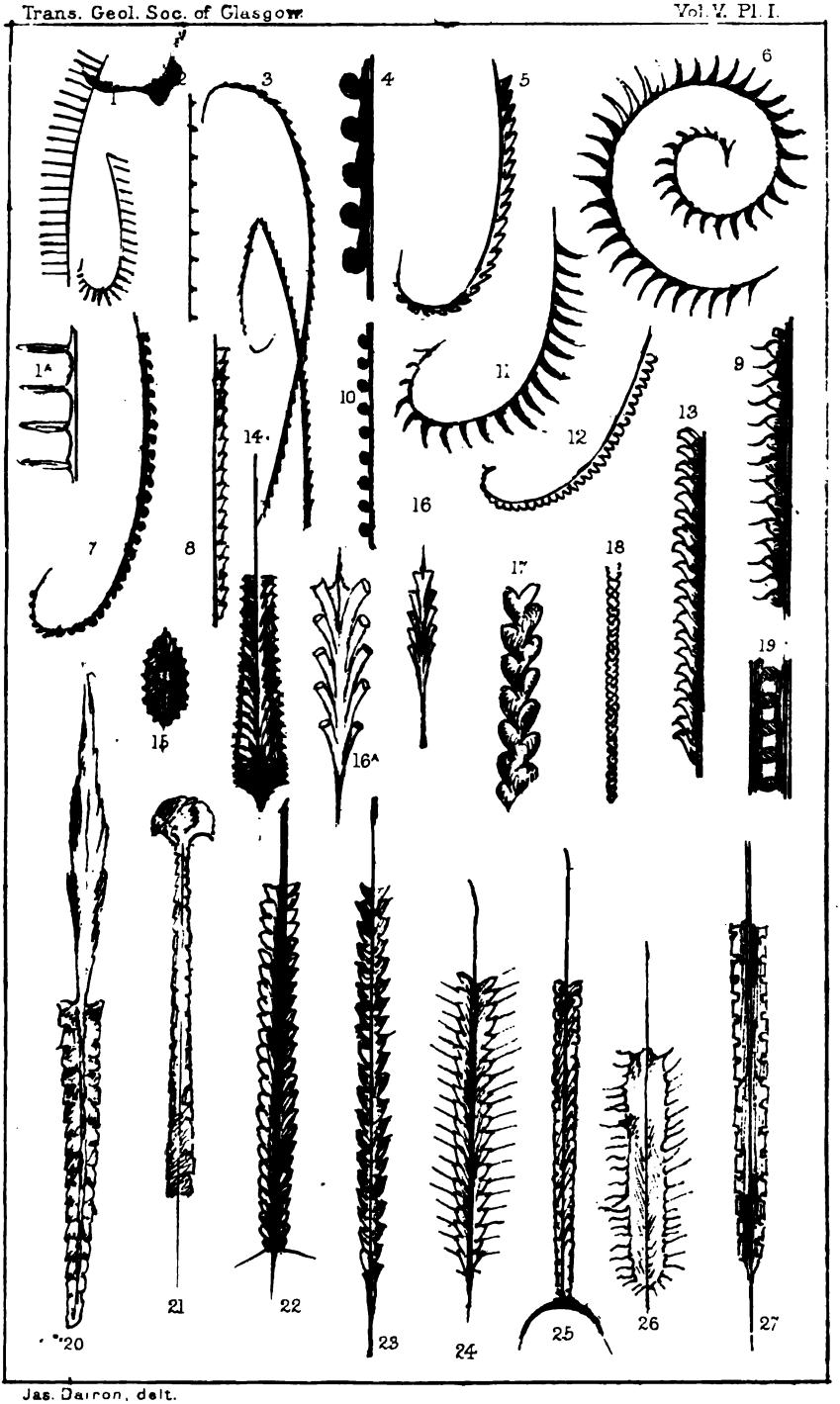

Jas. Dairon, delt.

Moffat, Graptolites.

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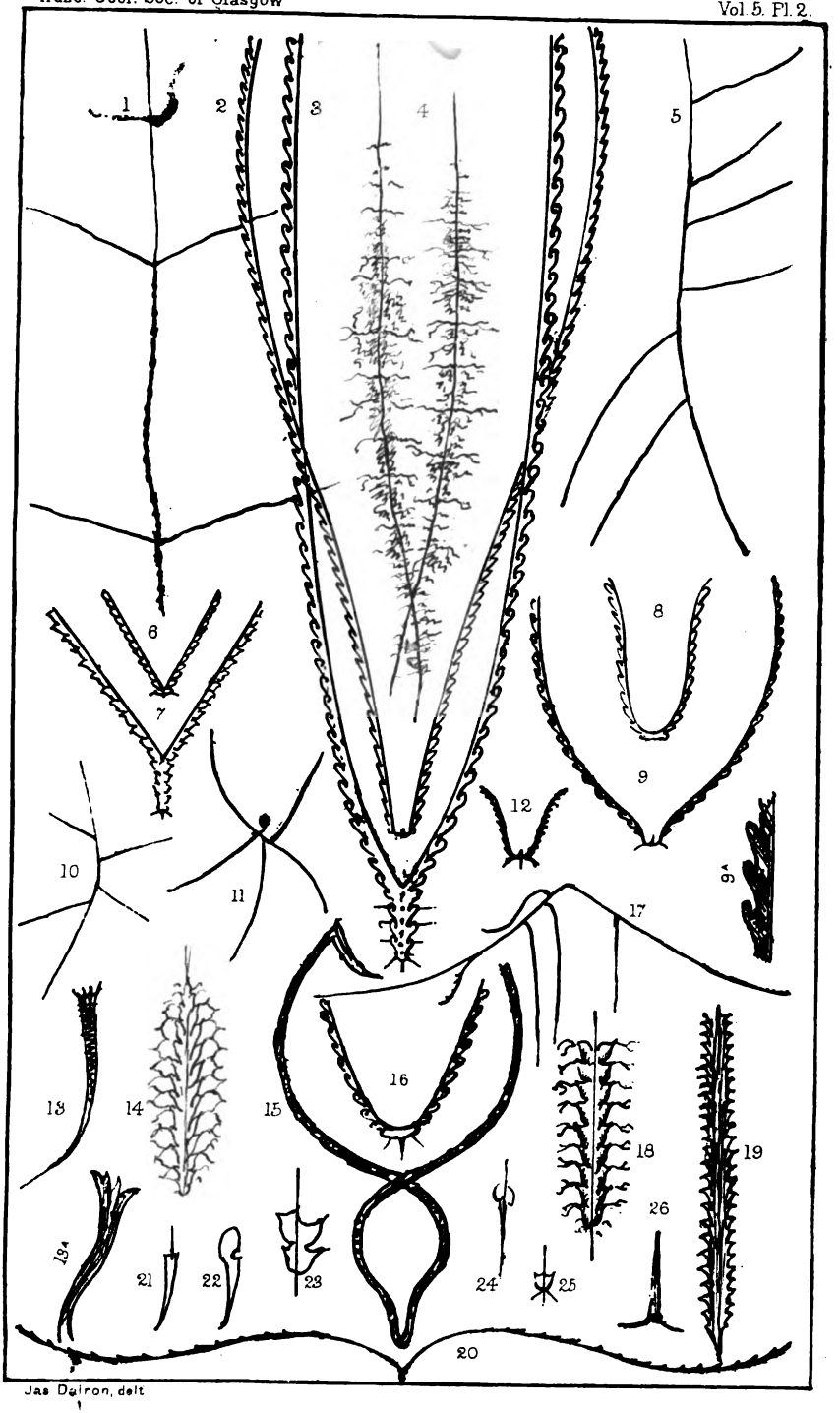

Jas Dairon, delt

Moffat_Graptolites.

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may be stated in order that their altered condition may be better understood when the facts of the present enquiry come to be detailed. What is usually called the roof, consists of a compact sandstone of from two to five fathoms in thickness; a few inches of gray clay shale, seldom exceeding a foot, separates the coal from the rock above. The shale above this coal has yielded few organic remains; in one place, above the shale, a flagstone two and a-half inches thick is found, having its under surface covered with casts of vermicular markings; at another, this flagstone assumes the form of laminated sandstone, some portions of which contain large quantities of sporangia or spore-cases of *Lepidostrobi.* Above Shotts "smithy coal"—equivalent to lower Drumgray—an inch or more of black shale sometimes occurs, from which I have collected a scale of *Platysomus,* a fragment of *Gyracanthus formosus,* and one *Anthracosia,* which constitute all the animal remains found in this bed.

The phenomena about to be described occur in a coal-pit forty fathoms in depth, lately sunk to the little Drumgray coal. After a pit has been sunk, it is usual to cut horizontal mines in various directions from the pit bottom, these being afterwards used as main roads for the conveyance of the product of the mine, and in one of these the first of the upright trees were discovered. The shale at the pit-bottom, above the coal, attains the unusual thickness of fourteen feet, the coal being of the usual thickness. The first mine is eight feet wide by seven in height, and after being driven a distance of about twelve fathoms, the coal, which had been observed gradually thinning, suddenly dropped to two and three inches: the shale likewise decreased in thickness, and when the mine was abandoned, had lost four feet of its original thickness. This mine being given up, new ones were driven in other directions, where the coal was found to be of the usual thickness, and as the work progressed, additional erect tree-trunks were brought to light, eight of these having now been found. In the first mine three were got at fifteen and twenty feet apart; another close to one side of the mine, the only one left in *situ,* the others having all been blown to pieces by the action of gunpowder. The trees all rest on the coal bed, and disappear in the shale forming the roof of the mine, but no opportunity has offered of observing if they enter the sandstone above. There is an interesting circumstance connected with these trees,—they all

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incline at a very small angle, and in one direction, or lean toward the "rise" of the strata, corresponding to the old water margin.

From the usual destructive operations of mining, no opportunity has been offered of ascertaining the existence of branches or roots; their height is also uncertain; the observed height is seven feet, and from their undiminished diameter at that height, the probability is that they passed through the whole thickness of the sandstone. There is, however, some negative evidence of roots seen in the tree already mentioned, as left standing in its original position, with the shale and coal connected with it, undisturbed, shewing a vertical section of the shale and coal, the tree in high relief in the foreground. In the shale at the base of this tree, thin lines of coal, about the thickness of a shilling, are seen radiating from the trunk outwards and downwards in the direction of the coal-bed, at the distance of one and two inches apart, and are probably root-remains.

All the trees are encircled by a layer of very fine coal, about a quarter of an inch in thickness, which is the thickest I have seen in connection with any vegetable remains, and would require about three inches of wood or woody matter for its formation: the data on which I have founded this calculation will be given below. On removing the layer of coal, the central core, which is composed of shale, has the colour and appearance of a highly-polished piece of jet, and has a slicken-sided appearance, but no striations or other mechanical markings are visible. The usual organic markings found on similar remains are here absent, and without this guide it is impossible to determine to what genus they belong. Markings or corrugations do certainly exist on the core, but they are so irregular in size and arrangement, that they appear to have resulted from irregular pressure, or shrinkage of the woody circle. The coaly cylinder is easily detached, and being the mould in which the core was cast, presents a reversed appearance. The outer surface of the coal has the same jet-coloured, fine-polished appearance as the inner, with longitudinal corrugations, which do not correspond with those on the inner surface.

How did this layer of coal receive the fine polish it now exhibits? On closer examination it was found that the coal itself is not polished, but has its surface on both sides covered by a thin coating of clay or shale, generally about the thickness of writing paper, but in some parts much thicker, and on this thin layer of

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clay, the polishing agent has acted. These polished surfaces I propose to adopt as evidence that these ancient trees possessed a central hollow, and a distinctly separate wood and bark; the wood and bark being now represented by a layer of coal, and the central hollow filled with shale.

The modern opinion, and the most rational one, is that coal beds were formed on land from the decay of vegetable matter, and were afterward submerged to receive their usual covering of water-borne shale and sandstone, so after subsidence the ancient forest under consideration—which must have been preserved in an erect position by some special local circumstance—would be surrounded by water holding in suspension large quantities of clay, the embryo of a future shale-bed. The layer of clay on the inner surface of the coal tends to prove a hollow stem, else no clay could have entered. The clay held in suspension by the water would naturally adhere to the woody surface, some chemical combination might take place between the alumina and the vegetable acids in the wood, forming a thin layer, which, if not already smooth, would be acted on by the water and clay in motion, as the polishing agent. Other proofs of a central hollow are not wanting; some are slightly compressed; one has part of its circumference pressed inward till it meets the centre of the stem. The shale-bed, as I have already stated, is fourteen feet instead of a few inches, and contains abundance of plant-remains. *Calamites*, with their foliage *Asterophyllites*, are plentiful; *Sigillaria* and *Lepidodendron* are also represented, but very sparingly.

In reviewing the physical aspects of this Carboniferous forest, some interesting problems present themselves, bearing on the physical history of that period. First, the thinning-out of the coal to two and three inches, suggests either a thin portion in the usual bed, or, that after its formation, it may have been washed away by some local current. Second, after the submersion of the trees, the hollow of subsidence must have been filled in a short time, or how could these fragile stems have withstood the corroding influence of "frost and fire" during the slow deposition of fourteen feet of shale.

I will now conclude by giving the data on which my calculations were based in estimating the quantity of peat or woody matter required to form a bed of coal. In these computations fractions have been laid aside. A number of years ago a pit was sunk to the

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slaty-band ironstone. The material first passed through consisted of twelve feet of moss, and on the mossy surface a hearth was formed, whereon the ironstone was calcined. This hearth was in use for several years, and from the heat and pressure of the burning ironstone, the moss gradually sunk, forming a considerable hollow. Ultimately a house was built at the place, and the old hearth was removed to form part of a garden, when it was discovered that the twelve feet of moss had been converted into twelve inches of good coke. The coke had the usual prismatic appearance, was dark coloured and hard, but did not shew much of the usual silvery gloss found on coke made from coal. It did not absorb water, or emit smoke when burning. Twelve feet woody matter equal one foot of coal.

XI.—*On* River Debris *found in* Sandstone. By William Grossart, Surgeon, Salsburgh.

[Read 11th March, 1875.]

At the present day, it may appear superfluous to bring forward proofs of the existence of rivers in Carboniferous times, and that these rivers carried in their flood the mud and sand which helped to form our shale and sandstone beds, but if we discover in the debris of these old rivers the remains of rocks containing animal remains brought from a distance, enclosed in a bed of sandstone—a circumstance seldom met with—another proof is recorded, and a new charm given to an old subject.

The following interesting phenomena, lately come under my own observation, occur in an open quarry where a sandstone above the Virtue Well coal is wrought for building purposes, affording every facility for accurate investigation. The sandstone in this locality is sixty feet in thickness, the usual thickness being a few feet, and in some localities absent altogether. The arrangement of the beds is as follows:—

1. Sandstone, 60 feet.
2. Bed of Gritstone, 2 feet.
3. Shale bed, 18 inches.
4. Laminated Sandstone, 10 feet.
5. Black Shale.
7. Virtue Well coal.

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I will describe these beds in regular sequence, beginning at the upper or highest.

1. *Sandstone bed.*—This bed requires no special notice; it shews divisional planes and false bedding, and when split up, a piece of drifted coal is occasionally found.

2. *Gritstone bed.*—This bed is composed of angular and rounded pieces of quartz, of the size of field beans and under, embedded in sand; is about two feet in thickness, thinning-out and disappearing near the rise-end of the quarry; being above the shale bed, is produced a few feet beyond it, and, as a sequence, rests on the laminated sandstone lying below the shale. When this bed is split by the workmen, remains of trees, pieces of black shale, and gas-coal are found enclosed: some pieces of shale measure nine by five by two inches, and are of frequent occurrence. The gas-coal is not so plentiful, and is got in smaller pieces, of one and a-half inch in thickness. Besides these, there are found numerous small rounded bits of what appears to be decomposed ironstone. On splitting some of the enclosed shale, I discovered fragments of *Anthracosia* and a small bivalve crustacean. This shale and gas-coal cannot have travelled very far; they are angular, and bear no trace of striations, and their original locality must have been below the Virtue Well coal. The Kiltongue mussel-band in this district, parish of Shotts, is found at sixteen fathoms below the Virtue Well coal, and would therefore crop-out at a higher level, and in a position liable to be carried away by the action of a stream. This band furnishes shale and gas-coal similar in appearance to that found in the grit bed. Of the animal remains the bivalve crustacean is common to other beds, but the *Anthracosia*, found in the drifted shale, belongs to what I call the smooth-shelled order, which I have never found in the upper Drumgray coal, or below it, and the probability is, that the drifted shale and gas-coal belong to the Kiltongue mussel-band. On comparing the grit bed itself with the Millstone grit found in the neighbourhood, they appear to be identical, with the exception of the enclosed debris. About a mile distant, and toward the out-crop of the strata, the Millstone grit beds, by a dislocation, are brought to the surface, and although their geographical extent is only a few hundred yards wide, they gradually broaden as they pass from Shotts parish, through Cambusnethan and part of Carluke parishes. The Millstone grit series in this district

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consists of beds of fine and coarse-grained sandstones, with intercalated beds of grit, and from the following statement, it will be seen that one half their thickness has been carried away. In a pit in this district, sunk to the slaty-band ironstone, a dislocation was come to in the usual operations for winning the ore, which brought the Gare limestone to the horizon of the ironstone, and from several bores put down to the limestone, it was discovered to have forty fathoms of stratified metals above it; and if, as is supposed, the Millstone grit series extends from the slaty-band to the Gare limestone, or one hundred fathoms, it is plain that about sixty fathoms of that series must have been carried away at some distant period. There is no proof, except from similarity in appearance, that the grit bed in the quarry was derived from the Millstone grit series, else it might have proved that the dislocation that brought these beds to their present position took place anterior to the formation of the Virtue Well coal. Another question here presents itself—Whether the upper coal beds, or those above the Virtue Well, ever extended beyond their present limits? If so, they would have been found resting unconformably on the eroded Millstone grit.

3. *Shale bed.*—This bed is eighteen inches, and thins-out and disappears under the grit bed. I have found no organic remains in this bed, nor any peculiarity worth noting.

4. *Laminated Sandstone.*—This is the "faik" or flagstone of the quarrymen, used for pavement, and is about ten feet in thickness; is composed of laminæ of white sandstone, varying in thickness, separated by fine, dark grey lines, all parallel to each other and to the planes of stratification, shewing that deposition took place in still water, or a slow-running stream. There are no ripple-marks, or organic remains found in this bed. It is easily split into pavement of any desired thickness, and when divided, one face is found studded over with pit-like markings about the size of one's finger point, the reverse having corresponding elevations. The markings pervade the entire thickness. Their first appearance would suggest the foot-prints of some animal, but on close inspection, although nearly uniform in size, they are seen to be so irregularly placed that they cannot be pronounced as such. A rain-drop theory has been proposed to account for these peculiar markings, but I believe has never been seriously entertained by practical geologists. A vertical section of the pits

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shews the laminæ quite in order, or very little disturbed, but under each pit they are bent out of position, as if pressure had been applied. This bending, in general, does not involve more than three or four laminæ, but in some instances they extend three inches vertically into the bed, and in this case the initial laminæ have the usual bent or semi-circular form, but gradually become pointed in the middle, and ultimately end in an acute angle, giving to the arrangement the appearance of an inverted cone, whose base is the width of the pit-mark.

The following additional particulars have come to light within the last few days:—In the usual operations for removing the flagstone, its ordinary character disappeared, and a solid bed of sandstone took its place,—not gradually, as might have been expected, but abruptly, like the step of a stair. This new bed is of that variety called "liver-rock," that is, shewing no lines of stratification, about a foot thick, and is not a continuous bed, but appears in patches of several feet across the strata, and a short distance to the "rise," and there gradually assumes its old form of laminated sandstone. On examination as to the probable cause, I found a line of large pieces of shale embedded in the rock, running across at nearly right angles to the "dip and rise," forming a partial weir, but how far this arrangement extended I cannot say, as the extent of the quarry is at present a little confined. Among the debris I found black shale, brown or paraffin shale, and coarse gas-coal. Some pieces of this shale measure two feet by four inches thick; one piece, still in position, is fourteen inches high, thickness unknown. The finding of brown shale in the debris strengthens my former opinion that the drifted shale was derived from the Kiltongue mussel-band, as this is the only bed in the district where brown shale is found. The appearance of the liver-rock so abruptly must be attributed to local causes; its position at the back or up-stream side of the weir, shews that the usual current of the stream must have been interrupted at this point, and the sand carried by the stream would settle down on the sheltered side of the obstruction, and the mud usually forming the grey lines of stratification would be carried away, leaving the sand in a pure condition; this is the more probable in consequence of the liver-rock extending but a short distance beyond the obstruction.

These are all the observed facts that I have been able to collect;

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they may be of some use to future investigators who may attempt to account for the formation of these peculiar markings.

5. *Black shale bed.*—This bed is not seen in the quarry, but in the same bed, half a mile distant, I got part of a tree, three feet long by five inches diameter, composed of white sandstone, which could not have been formed in black shale, but must have been brought from a distance,—that is, if fossil remains are generally converted into the same substance as the rock in which they are embedded.

From the facts above related, I conclude that the beds under consideration were formed at the mouth of a river flowing from east to west, at a period posterior to the formation of the Virtue Well coal; and taking as granted that the underclay was the soil on which the vegetation grew to form the coal bed, the conclusion is that dry land existed during the growth and decay of the coal-forming plants, and that the land afterward sank sufficiently to form the bed of a river, carrying in its flood the worn materials of older strata, which now form the roof, shale and sandstone, of the coal bed.

XII.—Notes *on a* Raised Beach *at* Cumbrae. By Mr David Robertson, F.L.S., F.G.S.

[Read 20th May, 1875.]

The late James Smith of Jordanhill was the first to point out a difference between the molluscan fauna of the post-glacial deposits and that of the raised beaches; also, that the fauna of the raised beaches was identical with that living in neighbouring seas, and that both of these deposits are anterior to the recent or historical period.

He says, "On one of my cruises* I had the good fortune to be accompanied by my lamented friend Edward Forbes. . . . . After visiting the Clyde deposits, we proceeded to Port Rush, on the Irish coast, where I had discovered a peculiarly rich deposit, collecting nearly 100 species in its raised beach, about 15 feet above the level of the sea. At the first glance, he exclaimed, 'Here is an end of your Arctic climate; these

* "Researches in Newer Pliocene Geology," 1862, pp. 76, 77.

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shells indicate a warmer climate.' Next morning he told me that he had been thinking over the climatal conditions of the Port Rush shells; that we were further out at sea than in the Clyde beds; the shells were, therefore, more pelagic in their character, and had a wider range. He would not, therefore, say that they indicated a warmer climate; but he could see no reason to suppose that they indicated a colder one. This was rather perplexing, as some of the shells were unknown to me; but upon the discovery of the last of these shells by Captain, now General Portlock, I became satisfied that there were two distinct formations."

No further search appears to have been gone into in regard to the fauna of these old beaches of Scotland. But be their age what it may, a decided break is established between them and the post-tertiary deposits, which contain Arctic shells not now living—or, at least, not now known—in our neighbouring seas.

Whatever variations of climate obtained during the whole deposition of the post-tertiary deposits, they do not appear to have left any decided impress of change on the molluscan fauna, no break that may not be satisfactorily accounted for by existing conditions. It is true that in some districts the post-tertiary fauna differs from that of another, at no great distance, in its apparently more northerly or southerly aspects, which unquestionably might arise from local causes, independently of climatal changes. The same thing holds good at the present time. For instance, *Fusus Tartoni* (Bean), *Fusus Norvegicus* (Chemn.), *Fusus Berniciensis* (King), and *Saxicava* (*Panopœa*) *Norvegica* (Spengler), all northern species, have been taken living on the coasts of Durham and Northumberland, while no trace of them has been found on the western coasts of Scotland. We may reasonably infer that similar variations occurred in the seas of ancient times, yet no one would ascribe them to change of climate.

Perhaps nowhere is the old twenty-five feet raised beach seen with more advantage than round the shores of the island of Cumbrae. Millport is built upon it, or, at least, upon a plateau regarded as belonging to it, though the greater portion is not half so high. From Kames Bay along to the south-west end of the island, a length of about one and a half miles, marine debris is seen lying in the greatest abundance. Elsewhere all round the shore it is generally comparatively bare, with only a little soil

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covering the rock, except a few gravelly patches here and there, and at two or three places clay with Arctic shells.

One of these shell beds crops up on the north-east side of Kames Bay; it is composed of hard reddish clay, and, from its dip, apparently passes under the sea. It lies between tide marks, but is seldom seen except when laid bare by storms. There is another Arctic shell bed lying at a higher level (32 feet above high water) on the west side of the College, where the shells are imbedded in sand.* It may be worth notice, in passing, that the shell sand of this bed was only reached, but not passed through. A short time ago, a well put down about twenty yards to the west of the old cutting, passed through the deposit, which proved to be only about a foot thick, and much more hard and compact than the over-lying sands. Under this firm shell-bearing sand, grey laminated clay, two feet thick, was cut into, and also contained Arctic shells; but, as it was not pierced through, its depth is therefore at present unknown. There is every reason to believe that this is the same bed which crops out in Kames Bay. Moreover, Arctic shells, such as the valves of *Saxicava Norvegica* and *Pecten Islandicus*, are often thrown up on the shore in Balloch Bay, opposite Fairlie, and at the west end of Fintry Bay. There can, therefore, be no doubt that all these patches of post-tertiary clays around the island are, or were, connected with the clays on the opposite shores, and those again with all others in the Clyde valley containing Arctic shells.

The area referred to of the Cumbrae raised beach is chiefly covered by the calcareous sea plant (*Melobesia calcarea*), locally known as "Marl."

The principal exception is the beach in Kames Bay, which consists of sand and gravel. In the sinking of a well there, about seventy yards inland from high water mark, six feet of fine sand were passed through, next one foot of peat, then seven feet of gravelly sand; a few hundred yards further back the sand thinned out on the peat, showing conclusively that all the sand over the peat in this place has been wind-drifted. The peat proves the existence of a fresh-water morass, which overlaid the gravel perhaps at no very distant date.

The portion of the beach to which I shall more particularly refer in this paper is that at the south-west end of the island,

* Trans. Geol. Soc. Glas., Vol. III., p. 113.

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exposed in a cutting for a new road near the battery, where many acres of the flat land consist chiefly of shell "marl."

The shells are mostly littoral, many more or less broken and water-worn. One moderately common is *Trochus lineatus* (Da Costa), and is of considerable interest, in so far as it is not known to be now living on the neighbouring shores. Its habitat is on stones near high water mark. Jeffreys records it from Dorset, Devon, Cornwall, Swansea, Anglesea, Channel Isles, Ireland as far north as Donegal Bay, and Spain. The following Scottish habitats are also given:—Dunbar (one specimen in deep water (Laskey); Peterhead (Macgillivray); Cumbrae (Smith); but Jeffreys thinks that these Scottish localities require confirmation. In reference to Mr Smith's find, there is now much reason to believe that he was right, from the fact that opposite this old beach has long been a favourite dredging ground of marine Zoologists; and as portions of this old beach are carried away by every storm into the sea, there is nothing more likely than that Mr Smith might dredge up one of these washed out shells.

As raised beaches occur near Dunbar, and probably at Peterhead, the above is a reasonable explanation of the finds at both these places.

The range of *Trochus lineatus* being confined to stones and rocks near high water, it could not be affected in any way by the shifting or transition of banks of one character into that of another, or other disturbances at the sea bottom, or by the changes in the depth of water. If due to change of circumstances at all, we cannot well suppose any other than atmospheric influences; and the fact that it is now more a southern than a northern species, favours the idea that a lower temperature prevails now than was the case when the shells of the old sea beach lived.

Tapes decussatus is another shell moderately common in the same beach, and not now found, so far as I know, round the shores of the island, though abundant on other shores at no great distance.

From the quantity of shells in the beach burrowed into by the sponge *Cliona celata* (Grant), it would appear to have been much more plentiful at one time than it is now, as recent examples of those species which suffered most from its attacks in these old beaches, are now rarely to be seen touched by it.

A land shell, *Helix nemoralis*, is not uncommon amongst the

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debris of this raised beach, and might have got there readily enough by being carried into the sea by rivers or streamlets, and again thrown up on the beach.

Another of these stragglers is a fragment of bone sent me by my friend Mr Levach, which he found in the same beach at a depth of six feet, and which was submitted to Professor J. Young, who pronounced it to belong to the right lower jaw of a young cow. Had the whole skeleton been found, it would be natural to suppose that the animal had been buried there purposely; but, as there was only a portion of a bone, it is more likely that it was deposited there along with the material in which it was found.

It may be remarked that *Melobesia polymorpha* (Linn.) is common in the post-tertiary clays of the West of Scotland, associated with Arctic shells, and is still more common, living all round our coast; but no trace of *M. calcarea* has been met with in these beds, although present in our old sea beaches, and abundant in our present seas.

It might be expected that the fauna of the old raised sea beaches would be exceedingly rich, where so much has been washed up by tides and storms,—where mollusca, polyzoa, ostracoda, and foraminifera have been floated up on the roots and stems of the large sea-weeds, and left on the shore to be disengaged as the plants decayed. But such accumulations of the remains of these ancient life forms do not seem to have taken place; so far as these old sea beaches have come under my notice, they are generally poor in variety, although occasionally one or two species may be very abundant. The scarcity of ostracoda and foraminifera, compared with the quantity obtained from an equal amount of material taken from the neighbouring sea-bottom, is particularly noticeable.

In regard to the age of these old sea beaches, although from the date of their formation till the present time there may be no change in their fauna sufficient to characterize a geological epoch, such as we have between the post-tertiary and raised beach deposits, yet the disappearance of the species above referred to is an inducement to extended research in the same direction for other facts that may lead to some satisfactory conclusion as to whether these variations are merely local, or brought about by more widely supervening influences.

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That some sub-aërial change has taken place at no very distant time, geologically speaking, we may infer from the fact that the remains of large trees are found in the peat of the Shetland Isles, where no trees will now grow. Sir Charles Lyell, in his "Antiquity of Man," refers to a deposit of peat in Denmark varying from 10 to 30 feet in depth, where remains of *Pinus sylvestris*, 3 feet in diameter, are found near the bottom; next is a layer containing the sessile variety of oak; next follows the pedunculated oak, and overlying that is the beech, a common tree in Denmark, but flourishing in places where the pine will not now grow. Whatever variations may have taken place in the temperature of our country, and whatever its effects on animal and vegetable life on land, since the formation of our raised beaches, such effects do not appear to have obtained appreciably at the bottom of the sea; one reason probably being that the range of temperature is vastly greater on land than in the sea. For the examination of doubtful species of the mollusca, I have to acknowledge my obligations to Mr Gwyn Jeffreys, F.G.S.

The list of species met with is as follows:—

Mollusca	66	species.
Crustacea	24	"
Annelida	2	"
Echinodermata	2	"
Foraminifera	17	"
Porifera	1	"
Alga	1	"
Total,	113	

MOLLUSCA.

CONCHIFERA.

Ostrea edulis (Linn.)	Common; moderately large.
Pecten maximus (Linn.)	Rather rare; large.
—— *opercularis* (Linn.)	Small and fragmentary.
Lima hians (Gmel.)	Rare; rather small.
Mytilus edulis (Linn.)	Moderately rare.
——— *modiolus* (Linn.)	Moderately rare.
Lucina borealis (Linn.)	Moderately common.
Cardium edule (Linn.)	Common.
——— *Norvegicum* (Spengl.)	Common.
Cyprina Islandica (Linn.)	One fragment.
Venus casina (Linn.)	Moderately common.

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Venus fasciata (Da Costa).	Common.
—— *gallina* (Linn.)	Moderately rare.
—— *ovata* (Penn.)	Rare.
—— *exoleta* (Linn.)	Moderately common.
Tapes pullastra (Mont.)	Common.
—— *decussatus* (Linn.)	Moderately common.
—— *virgineus* (Linn.)	Very common.
—— *aureus* (Gmel.)	Rare.
Tellina crassa (Gmel.)	Rare.
——— *Balthica* (Linn.)	Moderately rare.
Mactra subtruncata (Da Costa).	Moderately rare.
Solen ensis (Linn.)	A few fragments.
Pholas crispata (Linn.)	Rare.

GASTEROPODA.

Patella vulgata (Linn.)	Common.
Helcion pellucidum (Linn.)	Rare.
Tectura virginea (Müll.)	Moderately common.
Emarginula fissura (Linn.)	Rare.
Trochus magus (Linn.)	Very common and large.
——— *lineatus* (Da Costa).	Moderately common.
——— *cinerarius* (Linn.)	Common.
——— *umbilicatus* (Mont.)	Common.
Lacuna divaricata (Fabr.)	Rare.
——— *pallidula* (Da Costa).	Moderately rare.
Littorina littorea (Linn.)	Very common.
——— *rudis* (Maton.)	Moderately common.
——— *obtusata* (Linn.)	Common.
Rissoa parva (Da Costa)	Moderately common.
—— *costata* (Adams).	Rare.
—— *striata* (Adams).	Moderately common.
—— *cingillus* (Mont.)	Common.
—— *reticulata* (Mont.)	Moderately common.
—— *violacea* (Desm.)	Common.
Hydrobia ulvæ (Penn.)	Rare.
Skenea planorbis (Fabr.)	Moderately rare.
Cœcum trachea (Mont.)	Moderately rare.
Turritella terebra (Linn.)	Rare.
Scalaria communis (Lam.)	Rare.
Odostomia spiralis (Mont.)	Rare.
Natica catena (Da Costa).	Rare.
——— *Alderi* (Forbes).	Rare.
Aporrhais pes-pelicani (Linn.)	Rare.
Cerithium reticulatum (Da Costa).	Very common.
——— *perversum* (Linn.)	Rare.
Purpura lapillus (Linn.)	Very common.
Buccinum undatum (Linn.)	Common.
Fusus gracilis (Da Costa).	Moderately rare.

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Fusus antiquus (Linn.)	Rare.
Nassa reticulata (Linn.)	Moderately rare.
—— *incrassata* (Ström.)	Rare.
Pleurotoma rufa (Mont.)	Rare.
———— *costata* (Don.)	Rare.
———— *septangularis* (Mont.)	Rare.
———— *striolata* (Phil.)	Rare.
———— *Trevelyana* (Turt.)	Rare.
Cypræa Europæa (Mont.)	Moderately common.

CRUSTACEA.

CIRRIPEDIA.

Balanus porcatus (Da Costa).	Rare.
——— *balanoides* (Linn.)	Rare.
——— *crenatus* (Brug.)	Rare.
Verruca Strömia (Müll.)	Rare.

ANOMOURA.

Claw of Crab. *Sp.?*

OSTRACODA.

Pontocypris mytiloides (Norman).	Rare.
Cythere convexa (Baird).	Moderately common.
——— *villosa* (Sars).	Common.
——— *lutea* (Müll.)	Moderately rare.
——— *albo-maculata* (Baird).	Moderately common.
——— *angulata* (Sars).	Rare.
——— *pulchella* (Brady).	Moderately rare.
——— *pellucida* (Baird).	
——— *tenera* (Brady).	Rare.
——— *viridis* (Müll.)	Moderately common.
Cytheridea papillosa (Bosq.)	Rare.
Loxoconcha impressa (Baird).	Moderately common.
Xestoleberis aurantia (Baird).	Moderately common.
Cytherura nigrescens (Baird).	Common.
———— *angulata* (Brady).	Rare.
———— *flavescens* (Brady).	Rare.
———— *cellulosa* (Norman).	Rare.
———— *acuticostata* (Sars).	Rare.
Paradoxostoma ensiforme (Brady).	Rare.

ANNELIDA.

Serpula vermicularis (Ellis).	Common.
Spirobis communis (Flem.)	Very common.

ECHINODERMATA.

Echinus sphæra (Müll.), Plates of
Amphidotus, Spine of

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FORAMINIFERA.

Biloculina ringens (Lam.)	Rare.
Triloculina trigonula (Lam.)	Rare.
Quinqueloculina seminulum (Linn.)	Common.
——— *bicornis* (W. & J.)	Moderately common.
——— *secans* (D'Orb.)	Common.
——— *subrotunda* (Mont.)	Moderately common.
Spiroloculina planulata (Lam.)	Rare.
Lagena sulcata (W. & J.)	Rare.
Polymorphina gibba (D'Orb.)	Common.
——— *compressa* (D'Orb.)	Moderately rare.
——— *tubulosa* (D'Orb.)	Moderately rare.
Textularia sagittula (Defrance).	Moderately rare.
Truncatulina lobatula (Walker).	Moderately common.
Rotalia Beccarii (Linn.)	Common.
Polystomella crispa (Linn.)	Common.
——— *striato-punctata* (F. & M.)	Common.
Nonionina depressula (W. & J.)	Rare.

PORIFERA.

Cliona celata (Grant), burrows of	Common.

ALGA.

Melobesia calcarea (Ellis & Sol.)	Common.

XIII.—*On the* GEOLOGY *of the* ISLAND OF ISLAY.* By JAMES THOMSON, F.G.S., corresponding member of the Royal Science Society of Liége, Belgium. With a Map.

[Read 13th May, 1875.]

THERE are few parts of Scotland of which we know so little of the geological features as of those of the Island of Islay. The only information we have on the subject is to be found in Dr M'Culloch's "Highlands and Western Isles of Scotland," vol. ii., page 249; and by Prof. Nicol, in his "Geology of the North of Scotland."

Dr M'Culloch deals principally with the topographical aspect of the island, of which he gives a map and several sections. He describes the rocks in the central valley as being made up of

* The substance of this Paper was read at the meeting of the British Association in Edinburgh.

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TRANS. GEOL. SOC. GLAS.
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ISLAY

Jas. Thomson, Del.

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limestone, and notes the occurrence of granite boulders on the eastern side, and Prof. Nicol repeats these observations. But as neither of them identified the stratigraphical position of the rocks of Islay, the object of the present communication is to do so, and it will be best accomplished if I shortly notice, in detail, the stratified deposits. In order that their superposition and succession may be somewhat clearly defined, I have made a section of the most important points, which shows in succession the lithological order. I shall begin with the superior deposits on the south-eastern side, and review them downwards and westwards.

The southern end of the island is extended seawards in the form of a peninsula, which, from Slochd-mhaol-Doraidh in the north, to the Maol na h-Otha * in the south, is a distance of about seven miles, terminating at the Maol na h-Otha in bold water-worn precipitous cliffs, about 500 feet in height. The rocks here are quartzite, but on the south-west point, under Dunadd,† they consist of a gritty sandstone, with interstratified shales. The most notable of these is a band of chocolate-coloured argillaceous shale, imbedded in which are numerous masses of peroxide of manganese, varying in size from that of small peas up to pieces from 8 to 12 inches in diameter, the surface of these having a more or less mammalated aspect. These nodules, when broken, show radii of great beauty, and are delicately fibrous in structure. Their nucleus is usually of a different substance, sometimes appearing to be scoriaceous. In some instances the centre of the larger examples is broken up into irregular cellular chambers, which occasionally contain minute hexagonal crystals, of a delicate yellowish-green colour. If the manganese is dissolved in acid, it effervesces briskly. ‡

Masses of quartzite, made up of thin bands, are to be seen dipping under the sandstone, which overlies a thick bed of shale of a dark bluish-grey colour. This again overlies a series of beds of impure limestone, which splits up into thin flakes, some being

* Meaning Mull of Oa.

† Dunadd is the remains of an old fort, supposed by some to have been built by the Danes, on their way to the battle of Largs, A.D. 1263.

‡ It is worthy of remark that, since the above was noted, Prof. Sir Wyville Thomson has discovered manganese in a red clay bottom, at a depth of upwards of 3000 fathoms, in various parts of the ocean. May not the red shale of the Islay section have been deposited under similar conditions?

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not more than $\frac{1}{8}$ of an inch thick. Upon these flakes there are impressions of a very peculiar kind, some being attenuated to lines not thicker than the $\frac{1}{30}$ part of an inch, $\frac{3}{16}$ of an inch broad, and from 1 to 3 or 4 inches in length. They terminate at the opposite extremities in a somewhat clavate form; the structural characters cannot be made out in any of the examples that I have seen. *

On the east side of the Maol there is a deep gully, called Allt na meinne,† produced by a small stream, which has cut a channel into a bed of impure graphite, in which are imbedded large cubes of sulphate of iron. This bed is overlaid by a bold escarpment of limestone, broken up into thin bands. The graphite overlies a mass of gritty sandstone, which passes into a breccia, and, by almost imperceptible gradations, into an arenaceous chlorite slate, interstratified with thin beds of quartzite, together about 400 feet high, and all dipping to the E. by E.N.E. Near the base of this section the beds have been contorted in a most remarkable manner, yet their stratification has not been obliterated. They are seen to dip on either side into a deep synclinal trough, of about 100 feet deep. In the centre, and near the base, the rocks are all more or less shattered into splintered fragments: a result produced by a local disturbing agent, which I, with limited time, was unable to discover. It must, however, be very local, as the rocks in close proximity all more or less dip to the S.E., corresponding with the general dip of the stratified rocks in the neighbourhood.

Proceeding to the north, along the crest of the promontory, we pass in succession over the upturned edges of beds of quartzite, shale, limestone, and chlorite schist, until we reach Slochd-mhaol-Doraidh, on the west side of the point, where there is a mass of sandstone of a brownish colour, and in which we found patches of green carburet of copper, graduating into, and terminating on the shore in a coarse breccio-conglomerate. The sandstone is pierced and much altered by an extensive dyke of diorite, trending E. and by W. At the point of contact on the shore, the ceaseless roll of the Atlantic has abraded the under portion of the cliff, and has formed caves of considerable dimensions, where the chough and other rare birds resort during the breeding season.

* In outline these forms resemble some of the species of Graptolites.

† In English Ore brook.

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On the east side of the peninsula, in Port Ellen bay, the sandstone is again seen graduating into breccio-conglomerate, which consists of pebbles of quartz, varying from the size of a pea to three inches in diameter. It is there seen to be cut off by a syenitic diorite dyke, exposing, on the west side, the breccia, and on the east, a talcose schist of a dull red colour, with occasional patches of that silvery, metallic lustre so characteristic of this rock.

The schistose rocks trend eastward for about ten miles, and are seen all along the hill-sides, exposing in many places sections of contortions similar to those often met with in the lower Silurian rocks of the Highlands of Scotland. They contain, here and there, lenticular masses of white quartz, and steadily dip to the S.E. They are pierced by numerous igneous rocks, belonging to different periods of time, some being of a dull green colour, interspersed with large crystals of olivine and long crystals of hornblende. They seem to have been ejected through the strata at an early period, probably about the time the upper members of the Silurians were deposited, whilst the compact basalts and diorites have been thrown up at a much later date.* Their trend is from N.W. to S.E., and in many places they pierce the stratified rocks at right angles, and not unfrequently some of them cut through the older igneous rocks. Prominent amongst the later ones are those in the neighbourhood of Knockhill, to the north of Kildalton House. They have been ejected through the schistose rocks, and have shattered them into splintered fragments. Knockhill is composed of a syenite, with large crystals of hornblende; it is difficult to break, and takes a beautiful polish.

Bordering this coast of Islay is seen a succession of terraces, with, here and there, abrupt, rugged ridges, composed of the harder rocks which have resisted the abrading influence of the sea, giving this part of the island a wild and rugged aspect. But where the natural wooding has sprung up, as in the locality just mentioned, it gives the otherwise bleak moorland flat, with its rugged knolls, a picturesque beauty. All along the south-east portion of the island there is evidence of the erosive action of the sea at different elevations. Indeed, ridges and terraces may be traced, rising tier after tier, up to near the southern extremity of Beinn Urara. The schist rocks extend inland for three and a half

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miles, when they are seen to overlie a quartzite of a dull brown colour, intermixed with a pink variety. This quartzite may be traced passing through the mountain range to the north-east, and terminating in the Sound of Islay. Three miles to the north of Kildalton House, the junction is marked by a breccia, consisting of fragments of quartzite nearly pure white, with pink lines passing through it, intermixed and cemented together by a brown silicious matrix. It is seen trending S. and by W., and passing to the Sound of Islay, terminating near Sgorr nam Faoileann.*

A little way further inland we pass over an extensive ridge of quartzite, trending E. and by W., from Sgorr nam Faoileann in the east, where it assumes a series of bold, and more or less conical, mountains, the most conspicuous of which is Beinn Bhiogair,† 1600 feet above sea-level, with Beinn Mhain ‡ to the west, and Beinn Urara § to the south, 1400 feet high. It descends, in undulating slopes, to the south-west, terminating near Port Ellen, where the overlying quartzite graduates into the coarse breccio-conglomerate formerly referred to.

In passing northwards, on the west side of the island, we find the rocks more or less concealed by gravel and drifted sand for about eight miles,‖ until we cross the Laggan Water, where they again appear, in the form of a ridge of dull grey quartzite, trending S.W. by N.E., broken up into thin bands, and graduating into a dull bluish-grey impure limestone, succeeded by a grey slaty shale, with numerous imbedded crystals of iron pyrites, which crumble into fragments on exposure to the air, and all overlying a mass of quartzose chlorite schist, on the shores of Lochin dàla. These all dip steadily to the S.E., till near the village of Bowmore, where it is difficult to determine the dip and strike, in consequence of an extensive boss of dolerite, which has dislocated and shattered the stratified rocks into splintered fragments. To the east and west, however, of the igneous rocks, the

* Meaning Scaur of the Seagull.

† Meaning Hill of the vicar.

‡ Meaning Hill of the waste land.

§ Meaning Easily ascended hill; shelving out further in the range.

‖ As the trend of these rocks is from north-east to south-west, they are exposed on the north-east in water-worn cliffs along the shore of the sound of Islay. I shall therefore notice them in detail, when I come to describe the stratified rocks on the east side of the island.

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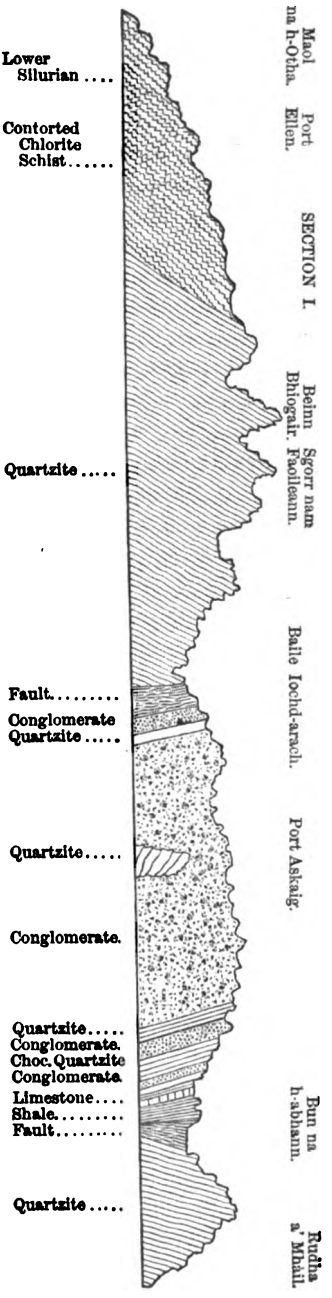
quartzites are seen steadily dipping to the S.E. To the west of Bowmore there is a band of arenaceous talcose schist, in which are found embedded fragments and boulders of quartzite, similar to those found on the east side and in the centre of the island, and which we shall note, in detail, by-and-by. These pass, by imperceptible gradations, into a chocolate-coloured shale, with interstratified chlorite schist of a corresponding colour, for a distance of about two miles, till at Gart breac,* where the stratified rocks are again much altered by intrusive igneous rocks, which here emerge from the sea. In trending westwards, the quartzites are more or less intermixed with those of a dull bluish-grey colour, varied with a pinkish variety, which at some places approximates to a felsite, until we reach Laggan point, where they are lost to view in the sea. It is noteworthy that these rocks are all more or less uniform, both in colour and composition, with those on the opposite side of the loch, suggesting a continuity of the same stratified rocks below the sea. This idea is rendered very probable by the fact that on each shore they are all more or less affected by similar igneous rocks. Indeed, on each side, the quartzites and schists are occasionally shattered into splintered fragments, and dip to all angles of the compass, varying from 15° to 70°.



* Meaning Spotted farm.

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Let us now take a cursory glance at the stratified rocks found in the centre of the valley, beginning in the north, and passing to Beinn Mhain, on the north-west extremity of that range of quartzite hills formerly referred to; and from the shore of Lochin dàla, on the west, from which the land rises with a gradual ascent, reaching an altitude of about 600 feet, and terminating in the Sound of Islay, in precipitous water-worn cliffs.

On the north side of the island there is a series of undulating hills, consisting of quartzites, and forming a continuous range all along the N.W. seaboard, from the N.E. point at Rudha a' Mhàil to Loch Ghruinnard, in the west, while the landward portion of the series terminates at Black Rock and Carnain. Indeed, the ranges of quartzite and stratified rocks trend from the shore in the east to the opposite shore on the west.

In the farm of Scarrabus the quartzite range is flanked and overlaid by a broad belt of sandstone, containing minute crystals of iron pyrites, which in turn is overlaid by an impure limestone, made up of numerous thin bands, and these pass with imperceptible gradations into the overlying calcareous shale which, on exposure to the weather, splits up into thin flakes, and all dipping E.E. S.E. ang. 44°. These calcareous shales become more arenaceous, and finally pass into a fine-grained quartzose sandstone, which is overlaid by a broad belt of bluish grey quartzite, which trends to the S.W. and terminates on the shore of Lochin dàla at Carnain. This again is overlaid by a belt of soft chlorite schist, of a dull grey ochrey colour, which, when exposed to the weather, splits up into thin scaly fragments, the dip being E.E. S.E. ang. 61°. Above it lies a bed of limestone, which in turn is succeeded by a series of thin beds of arenaceous chlorite schist of a dull ochrey colour, capped with a dark blue quartzite, which forms a conspicuous ridge, and is seen trending to the west, and terminates at the north corner of Lochin dàla, near Islay House.

In the farm of Octovulin this quartzite passes into a dull grey sandstone, which is overlaid by an extensive bed of a greyish purple arenaceous talcose schist, containing numerous minute crystals of iron pyrites. Interspersed throughout this schist are rounded and angular fragments and boulders of granite, gneiss, and white quartzite, which may be termed a breccio-conglomerate, which when exposed to the weather, becomes of a reddish brown colour, with ferruginous stains along the joints and planes of

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stratification; its dip is E.S.E., ang. 28°. This is overlaid in the farm of Skerrols by a broad belt of limestone, made up of thin bands, intersected with numerous ramifying veins of calc spar, and interstratified with partings of arenaceous shale; its dip is S.E. ang. 34°, and its trend N.E. to S.W. from near the Sound of Islay in the north, and terminating south of Bridgend Hotel,* on the shore of Lochin dàla. This limestone is overlaid by chlorite schist, and is only seen at intervals, as it is concealed by moss and surface vegetation. It is, however, well exposed in the banks of the river Sorn, in the wood below Dail's farm house. To the south, which is covered by an extensive band of limestone with occasional partings of arenaceous shale, and seen trending to the S.W. and exposed in a cutting on the road from Bridgend to Port Ellen. In ascending the rising ground to the south, the limestone is more or less exposed till it reaches the farm of Nerby, where it is interstratified with bands of chlorite schist, of a chocolate colour, its dip being E.S.E. and angle 75°. It is capped by a ridge of quartzite trending E.N.E. to W.S.W., of which the dip is S.S.E. and the angle 68°. To the S.E. the quartzite is succeeded by a bed of clay slate, containing large crystals of iron pyrites. This quartzite, limestone, and chlorite schist, form a prominent ridge, and cross the Port Ellen Road to the W.S.W. (as formerly referred to), and terminate in the shore at Laggan farm. In descending the valley to the S.E. of Nerby farm, a band of impure limestone is seen overlying the clay slate, with an abrupt termination, caused by the erosive action of the sea when the valley and strath were all under water. The well-marked terraces of sand and gravel on either side give ample testimony that they were deposited in a post-pliocene age, while here and there the harder rocks are left as prominent knolls, the interstices being filled with peat-moss and brown heath. On the crest of one of the most prominent of these ridges are to be seen the remains of a Danish fort of considerable dimensions. It is of an elipsoid form, showing a series of earthen outwalls, with an inner quadrangle 84 feet long.

In passing to the S.E. the stratified rocks are concealed by boulder drift. The clay is of a light bluish-grey, containing angular, subangular, and rounded boulders of limestone, quartzite

* This is perhaps one of the most charming spots in the West Highlands; and there is a very comfortable hotel.

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of various colours, dull green dolerite, with large crystals of pale green olivine and hypersthenic syenite. About half a mile to the S.E. a limestone is again seen interstratified with clay slate, chlorite schist, and quartzite, until we come to the Shean river, along the banks of which are exposed rocks of a similar character until near the top of the glen, where there is an extensive mass of saccharine limestone, which in some places is nearly white, passing into a pinkish grey variety. This is broken up in the upper part of the exposed section, with thin bands interstratified with arenaceous shale, in which, though searched with care, I have not yet found organic remains, but I do not yet despair of doing so. Along the line of junction, the quartzite is seen to overlie the saccharine marble and calcareous shales. Several of the mountain streams have eroded deep underground channels into the calcareous rocks, and are lost to view for a considerable distance, again re-appearing in the banks of the river Shean. One of the caverns made in this way is of considerable size. This limestone is seen crossing the valley and ascending the steep slopes of Beinn Mhain, and may be traced for miles trending to the S.S.W. On the eastern extremity it is much altered and shattered by a broad dyke of dolerite of a dull green colour, containing pale green crystals. At the point of contact the igneous rock is not only lighter in colour, but is also finer in crystallization, and trends from N. to S. It can be traced for a considerable distance to the north, and to the south it is seen descending and crossing the upper reaches of the river Shean, being there lost to view in the talus and remains of ice-drift, until at an altitude of 1340 feet, where it is 16 feet broad, and where it has been ejected through a brecciated quartzite, which at the point of contact is shattered into splintered fragments, with the igneous rock filling up the interstices, and mixing with the breccia. The junction is seen for about 100 feet higher, where it is again lost, re-appearing at the height of 1560 feet, and to the summit of Beinn Bhiogair, is then exposed 1600 feet, where there is evidence that here was a centre or vent of volcanic force, as the rocks around are all shattered into splintered fragments.

At the upper extremity, and a short distance to the north-east of the glen, there is a deep basin, in the middle of which lies a small loch called Loch Allaly, with a little island in the centre. This loch is bounded on the west by the igneous rocks just referred to,

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and on the east and south-east by gritty quartzites, which rise in terrace after terrace like cyclopean walls. On the east lies Sgorr nam Faoileann,* which is fully 1400 feet high. Then passing to the south we find a ridge of brecciated quartzite at least 1000 feet high, and formerly the water-shed between Glen Choridale† on the east, where the descent is steep and rugged, and Glen Shean on the west, while to the south it joins the steep and rugged side of Beinn Bhiogair, which, as previously stated, is shattered into splintered fragments by the action of the igneous rocks. On the south-west face the quartzite and breccia are of a dull red or pinkish tint. They continue down into Glen Shean, and emerge on the north face of Beinn Mhain, the dip of the quartzite—where not affected by igneous action—being steadily to S.E. Indeed, if the observer passes from the lofty summit of Beinn Bhiogair, and across the ridge to Sgorr nam Faoileann to the north, the quartzites can be traced passing through the body of the hill to the S.E., and terminating on the opposite or the rugged and precipitous face of Glen Choridale, while to the north on Beinn Mhain, and to the south all along the range to Beinn Urara, and Beinn na Cailliche † on the south-east, the quartzites are seen still dipping to the S.E.

The long axes of the ranges form conspicuous ridges throughout the island, the general trend being from N.E. to S.W., while the depressions are all more or less filled up with schist, slates, and limestones. In Glen Shean, on the west, these stratified rocks are here and there seen, and dipping to the S.E. On the farm of Kinnagary, on the side of Beinn Mhain, the junction of the overlying quartzite, and the calcareous deposits can be traced by the marked change in the vegetation. All along the strath the limestone rocks may be traced by the soft green surface-growth, while above the quartzites the shaggy heath and stunted scanty grasses show how poorly the soil, resulting from their decomposition, supplies the elements favourable to plant life.

The stratified rocks which we have thus briefly reviewed, and which are seen to overlie the great body of quartzites on the north-west side of the island, and occupying a space of about six miles, all steadily dip to the S.E., at angles varying from 28° to 75°. If, however, we take the average of the angles of dip, we have 33°, almost equal to one-third of 100°, and in the same way divide

* Meaning Glen of the caldron pool.

† Meaning Hill of the old woman.

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the six miles of extent by 3, we have two miles, so that if these six miles of deposits, dipping at an angle of 33°, be placed at right angles to the plane of stratification, they will represent two miles, or 10,560 feet of sedimentary rocks, which fill up the central valley, reposing on the quartzites in the north-west, and overlaid by the great body of quartzites in the centre of the island.

I now propose to notice shortly the stratified deposits from Baile Iochd-arach * in the south, to Bun na h-abhann in the north, where they are all exposed in an ascending series on the sea-cliffs, dipping N.N.W. At Port Askaig a ridge of dull blue quartzite is seen in a bold precipitous face, 70 feet in height. It is made up of more than a hundred thin bands, varying from two inches to two feet in thickness, and trending W. by E., the dip being N.W., and the angle 12°. Underlying this, the shore is fringed for 3½ miles by a series of sedimentary rocks, consisting of a dull bluish-grey arenaceous talcose schist, exhibiting faint lines of stratification, whilst in other parts of the section it resembles the unstratified deposits of more recent times.

On the north side of Little Free-Port Bay, blocks were recently being quarried to build a new pier at Port Askaig, which exposed a section about 100 feet deep, and showing numerous imbedded fragments and boulders of transported rocks. At its base there is a dull bluish-grey arenaceous schist, shading, as it passes upwards, into a light brownish grey. In the earlier stages of the deposits the matrix had been soft and plastic, into which the transported fragments and boulders had been dropped, with subsequently a great influx of arenaceous matter. It thus passed with almost imperceptible gradations from a stiff blue talcose mass in the inferior, to a gritty sandstone in the superior deposits. There is, therefore, evidence of great physical changes throughout. The contained pebbles and boulders are frequently well water-worn, others subangular, whilst others again are angular. They chiefly consist of granite, quartzite, and rarely gneiss. Some of the granites much resemble a variety met with in the range of mountains to the south of Ben Nevis. It is of a dull red colour, the greater portion of its mineral constituents consisting of a reddish felspar. In this section the heaviest blocks and finest particles are commingled, and form a confused mass, in which I have detected not less than thirty-seven varieties of granite, and a

* Meaning Nether farm, or Netherton.

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few examples of gneiss. Over and around the boulders the schist is deposited evenly, while inferior layers are squeezed downwards, crushing and destroying the planes of stratification. It is noteworthy that I have not found a single specimen of trap rock in this section. The granite fragments largely predominate, and vary in size from the smallest pieces possible to boulders as large as 4 feet 10 inches in diameter. I estimate the proportion of quartzite approximately to that of granite as 1 to 15. After a careful examination of the shore, and of the blocks embedded in the matrix, I am satisfied that these erratics could not be traced as belonging to any part of the island. Similar rocks do not occur *in situ* nearer than forty miles to the north, in the island of Mull, with a deep sea intervening, while some of the varieties only exist at a considerably greater distance. The entire absence of stratification in one part of the section, which in another shows signs of regular deposition, and the occurrence of far transported rocks of the character already stated, indicate that the mass had been transported and dropped from melting ice in a shallow, tranquil sea, the bottom consisting of mud and sand. The absence of stratification in one part of the section may be accounted for by the disturbing action of icebergs which moved to and fro, grounding as they went before they were finally stranded. I was, however, anxious to find further proofs of ice action, such as well-marked striations on rock surfaces would afford, but such evidence was of course obscured by subsequent depositions, and only on those parts of the ancient rock-surfaces which had escaped destruction by denudation could such striations be found On the north side of Little Free-Port Bay the quarrying operations already spoken of had laid bare a piece of transported quartzite rock, the surface of which was ground, smoothed, and striated, and as perfectly preserved as in rocks of more recent times.

The deepest section of the conglomerate exposed from the shore line to the crest of the water-worn cliffs is 130 feet, and is capped by quartzite bands graduating into a gritty sandstone, which passes into a brecciated conglomerate,* evidently an old shore line of sand, and containing transported fragments and boulders of granite, and traceable inland to an altitude of 180 feet, where

* It has been suggested that marine plants might have been the agent of transport, but in regard to blocks of a size here found, such a theory is not admissible.

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its upturned edges are exposed, curving round the hillside in a semi-circular form, and dipping to the N.W., the ang. being 48°, and again bending down to the shore line at Port Askaig Hotel, where I first discovered the remarkable erratics above described. It then trends to the S. at Baile Iochd-arach, a distance of about two miles, and is there cut off by a diorite dyke. In rounding the point into Big Free-Port Bay, the gritty sandstone is seen to be overlaid by an extensive bed of quartzite, broken up into thin bands, which are found ascending the hillside and folding round the underlying deposits, and also passing to the south, and bending down to the shore at Rugha an t-Salainn, where the planes of stratification are much affected by a syenitic greenstone dyke trending W.N.W. by E.S.E. Indeed, the stratified rocks seem to have been deposited over and around the dark bluish-grey quartzite at Port Askaig, which seems to be the only fragment left of the old shore line, and is probably of pre-Cambrian age. They all dip N.W., while to the south, along the shore, the quartzites and stratified rocks dip steadily to the S.S.E. The frequent occurrence of igneous rocks in the neighbourhood of Rugha an t-Salainn, and the marked alteration in the dip of the stratified rocks there—the stratified deposits dipping to the N.W. on the north side of the line of fault to near Keills, while on the south side they dip to the S.S.E. This indicates that here we may trace and account for the throwing up of the underlying drifted matter to the surface, while on the north-west side of the island, at Skerrol's farm, similar drifted materials are found to underlie all the calcareous and stratified rocks of the centre of Islay. This, however, will be better understood when we pass in detail the stratified rocks to the north of Port Askaig.

In passing to the north of Big Free-Port Bay, the quartzite is overlaid by a band of talcose schist, which in turn is overlaid by a succession of thin-bedded greenish-grey micaceous sandstone flags, interstratified with dull chocolate-coloured argillaceous partings. The surfaces of these flags are not unfrequently covered with sun-cracks, with upturned edges of various forms and sizes, the result of shrinkage from sun heat, and which are subsequently filled up with, and silted over by, the influx of sedimentary matter. They also contain ripple marks, in the depressions of which are numerous little pits, with upstanding edges, varying in size from half a line to two lines in diameter. These possibly are

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the impressions of rain-drops found in the soft partings during deposition. This section is fully 100 feet deep, and is overlaid by a series of pinkish-coloured quartzite bands, which again are covered by sandstone, calcareous shales, and impure limestones on the farm of Aird na hughadh.

This depth of calcareous accumulations is followed by almost purely arenaceous deposits, which mingling with the later sediments of the preceding formations, produce near the junction of the two, a calcareous sandstone. It is overlaid by quartzite, which is cut off by a diorite dyke. On the north side of the dyke there is a mass of arenaceous schist about 200 yards broad, containing fragments and boulders of granite. At first sight I thought these deposits might be a continuation of those beds further to the south, which had been brought up by the diorite dyke just referred to, but after a careful examination of the surrounding strata, when I found the matrix of the latter to be of a more gritty character, I am inclined to place them higher, which would indicate a repetition of similar conditions at great intervals of time. Indeed, the phenomena occurring at several points along the coast line, however local they may be in their extent, point to physical changes similar to those of more recent times.

These deposits are succeeded and overlaid by a broad band of quartzite, which dips 25° to the N.W., and are followed by calcareous shale and impure limestone, with interstratified bands of quartzite. This is overlaid by beds of gritty sandstone, of a dull brown colour, interstratified with calcareous partings, to which succeeds a dull grey quartzite, which in turn is capped by a broad belt of dark slaty shale, interstratified with thin quartzite bands, which vary from one inch to several feet in thickness, and interlaminated with dark grey shale, containing imbedded crystals of iron pyrites. These, when exposed to the weather, become yellowish-brown, rotten rock, splitting into thin layers; their dip is to the N.W., 72°. This high angle is produced by a diorite dyke. These sedimentary rocks pass inland, bending with a gentle curve to the south, and are found on the crown of Knock Aird na hughadh, formerly referred to. They trend to the S.W., and are seen at Shanes Hill, and westward to Skerrols. At the Maol of Aird na h-abhann they are again seen to be overlaid by quartzite of a dull brown colour, its dip being to the N.W., at an angle of 68°, which at 200 yards from the point of the Maol,

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graduates down to an angle of 25° N.W., and there plunges below sea level in the Bay of Bun na h-abhann.* It re-appears on the opposite shore at Beachie Point, where it rises with a reverse inclination, the dip being S.S.E., ang. 47°, and passes to the north in a series of bold conical mountains. The centre of this bay is a synclinal trough, where the quartzite is a white vitreous mass, crushed and shattered into splintered fragments, it being almost impossible to detect the planes of stratification. At first sight I thought the quartzite on the north shore of the bay was unconformable to that on the south, but after a careful examination, I am disposed to think that it was one continuous super-imposed mass, and that the centre of the bay is the line of a great downcast fault, trending S.W. by N.E.

As before noticed, to the south of the conglomerate section the quartzites (as in the north) rise into a series of bold conical mountains, and is seen forming the steep slopes of Beinn Dhubh† in thin bands, which are seen folding and clasping round the dull red breccia which forms the nucleus of this part of the range. The valley of Rugha an t-Salainn is a line of fault; on the north side the dip of the quartzite is N.W., while on the opposite side of the valley it is to the S.E. The quartzite here overlies the eastern extremity of the saccharine limestone, which terminates a few feet from the Sound of Islay, and trends to the S.W., in Glen Allaly. A few hundred yards inland the saccharine limestone overlies other calcareous deposits, and the soft interstratified shales have been eroded away, leaving the hard upturned edges of the quartzite and limestone as prominent ridges facing northwards, and which, although covered by vegetation, can be traced along the hillside, rising terrace after terrace, like the more recent raised beaches.

In observing the outcrop of these rocks along the shore line from Baile Iochd-arach on the south, to the Maol of Bun na h-abhann on the north, it will be seen that though they present considerable changes in the lithological characters, their general succession is very similar to those of the transverse section on the north side of the centre of the island. The dip and strike of these beds differs so widely from those of the south and central portion of the island, that the idea is suggested of some

* Meaning Outlet of the water.
† Meaning Black Hill.

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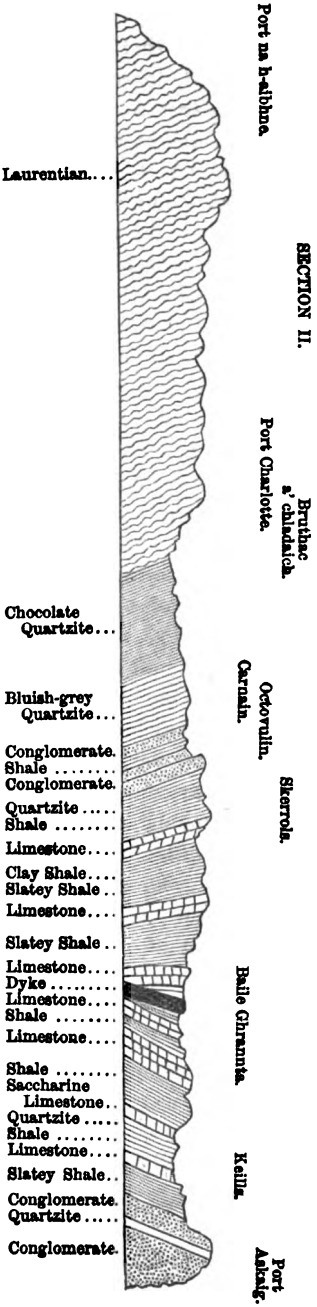
great physical agency, which had been the means of producing such divergent results. All along the eastern shore line, and for a short distance inland, the general dip of the beds is to the N.W., while in the south and in the northern part of the island the dip is to the S.E. The only probable cause that I can assign for these deposits dipping at right angles to each other, is the frequency of the diorite dykes. In the neighbourhood of Baile Iochd-arach, where the line of fault is so well seen, the trend of the dykes is from S.S.E. to N.N.W., and they all more or less converge inland to the centre of the valley, lying to the north of Baile Ghrannta, where there is evidence of some great local disturbance by volcanic agencies, and which seems to have been the centre or volcanic vent from whence the igneous masses have been erupted through the stratified rocks, and which had upraised the underlying conglomerates and super-imposed stratified deposits. This is confirmed by the fact that along the line of fault is a line of depression which extends inland to the north of Baile Ghrannta, and then trending to the N.E., terminates at Bun na h-abhann Bay, thus inclosing in a somewhat triangular form the upraised lower deposits, which are now exposed along the shore line. Subsequently the overlying stratified rocks have been denuded away by ice-action and by that of the sea.



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In order that the relation of these deposits may be clearly understood, let us take a cursory glance at the stratified rocks from the east to the west side of the island. In following the track of the high road from Port Askaig on the east to Port na h-aibhne on the west, we pass over the upturned edges of the stratified rocks, most of which have been already mentioned in crossing the centre of the island, in a somewhat diagonal manner. Going westwards from Port Askaig for about a quarter of a mile, we pass over the upturned edges of chlorite schist, quartzite, brecciated conglomorate, micaceous flags with felspathic partings, and a body of quartzite which forms the crown of the ridge. In descending from this to a small valley, we find the stratified rocks concealed by the super-incumbent vegetation. We believe them, however, to be a continuation of the calcareous shales seen on the shore line beyond Big Free-Port Bay. Overlying this there is a broad belt of limestone of a dull blue colour. This limestone, when exposed to the weather, shows a granular or oolitic appearance, which I thought might be due to minute organic forms. I had some of the most promising specimens sliced for the microscope, and on examination, found the granular form to consist of small spherical aggregations of iron pyrites through the matrix. This limestone is broken up into thin bands, with interstratified thin beds of gritty shale, and then passes into light buff-coloured saccharine limestone, which in turn is overlaid by quartzite of a similar colour. These all dip to the N.W., and pass into a pinkish colour at Keills. Further to the west we pass over thin bands of quartzite, interstratified with dark shale. These quartzites vary from an inch to several feet in thickness, and trend N.E. to S.W., the dip being S.E. At about a mile to the east they are again seen in the crest of Knock Aird na hughadh, at an elevation of 480 feet, their upturned edges being there exposed, with a dip to N.N.W., the angle being 72°. These rocks within a limited area dip at a right angle, which has been produced by a diorite dyke, formerly referred to as passing along the line of fault north-west from Baile Iochd-arach. A short distance to the east, we pass over the most extensive body of limestone in the island, and which has long been mined for galena. It is interstratified with dark shale partings, and is overlaid by a dark slatey shale, which is more or less seen till we reach Baile Ghrannta, where there is a broad dyke of diorite erupted through a bluish lime-

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stone, which is made up of thin bands with partings of micaceous shale. The dislocation produced by the intrusive dyke is of limited extent. On its west side the limestone is thrown up at right angles to the plane of stratification, whilst on the east side the beds dip at an opposite angle—*dip* E.S.E. To the west for about half a mile, the upturned edges of the hard stratified rocks are occasionally seen in rugged knolls, while the intermediate spaces are filled up with boulder drift, and super-imposed vegetation, till we reach Shanes Hill, the western slopes of which consist of quartzite. On the east side there is a succession of dark slaty shales, interstratified with impure limestone. These stratified rocks are much affected by an intrusive diorite dyke; the alteration caused by which, however, is local, the general dip being S.E. For a distance of nearly three miles, the stratified rocks are much concealed by ice drift. The majority of the boulders are traceable as having come from the west, and are all more or less scratched and polished, the usual accompaniments of ice action.

To the west, and in the neighbourhood of Islay House, there is an extensive belt of quartzite of a dull bluish colour, which, as before stated, trends to the west, and is seen on the shore of Lochin dàla, near Bridgend Hotel. Along the shore to the west the arenaceous talcose schist, with imbedded fragments and boulders of granite, are seen in the wood, are lost under the sea, and re-appear to the west of Bowmore village, on the opposite side of the Loch. They are overlaid by a dull bluish quartzite, which at Carnain is seen to pass inland and form a ridge, some of its hills being of considerable height. To the west the underlying stratified rocks are concealed by gravel and drift sand for a distance of two miles. The pebbles exhibit all the varieties of quartzite, from a bluish-grey to an almost pure white. Going inland towards the north, and along the low flat-lying strath of Ghruinnard, where lie the upper reaches of Loch Ghruinnard, the subsoil of the strath is made up of recent shells for a depth of from four to five feet. On the north-west side of the strath the rocks exposed consist of quartzites and chlorite schists, all more or less of a chocolate colour, till at Sanaig hills, on the shore, they end in bold water cliffs, the highest of which is somewhere about 600 feet. The stratified rocks are here seen to pass into a bluish-grey chlorite slate. These slates are often crushed and broken into every conceivable angle by intrusive igneous

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rocks, consisting of compact basaltic diorites. One of these dykes is 12 feet broad, and the columns are lying horizontally. All along the shore line, and at the junction of the igneous rocks, the stratified rocks are eroded away into deep gullies, one of which is called Gairtean Ghille Mhoire; it is about 400 feet long, and at the deepest part about 600 feet in depth, that is from the crest of the hill to the shore line, and twenty feet broad. At the upper portion of the gorge the rocks consist of a dark blue brecciated shale, while seawards they are arenaceous chlorite schist, interstratified with blue gritty quartzite. These all dip to the S.S.E., and present on the shore line a series of rugged cliffs. In passing inland and to the S.W. the rocks dip to S.E., till we reach Balinaby,* where, however, the angle of inclination is seen to alter near the parish church of Kilhoman, being the dip to the N.W., and the quartzites, schists, and slates are seen to overlie and fold round the gneissic rocks, of which the western extremity of the island is made up. On the east side of the ridge Bruthac a' chladaich,† the talcose schist and quartzites are more or less of a light chocolate colour, and are seen dipping to the S.E. They are here cut off by a felspathic dyke of a dull red colour, trending N. and S., which a few yards inland is covered with sand and gravel. A little to the south-west there is a compact diorite dyke, erupted through the stratified slates and gneissic schists, and it has crushed and destroyed the planes of stratification, the dip being to every point of the compass. At this point a complete change both in mineral character and physical conditions takes place. There is a band of felsite of a pinkish colour, with lenticular masses of white quartz imbedded, and crushed into splintered fragments, the result of the neighbouring intrusive igneous rocks. The gneiss is here overlaid by a band of clay slate, which may be traced passing through the promontory to Cille Chiaran on the west shore, where it has been quarried for roofing purposes. It is seen clasping and folding round the gneiss, and in turn is overlaid by an extensive mass of quartzite to the north, which dips N. 82°.

Inland, about 200 yards from the slate quarry, the gneiss is pierced by a hypersthenic syenite dyke, trending W. by E., being tilted up nearly at right angles to the plane of stratification a short distance to the south. For about two

* Meaning Abbot's farm.

† Meaning Hill on the Shore.

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miles, the gneiss dips S.S.W., till on the south-west of Cladvil hill it is seen dipping W.S.W. In descending to the plain we pass over a broad belt of highly metamorphosed gneissic chlorite schist, which graduates into a granitic gneiss, varying in colour from a dull green to a pinkish variety.

From Bruthac a' chladaich along the shore line to Port Charlotte and to the western end of the peninsula, where a few hundred yards out there lie two small islands, upon one of which, the island of Oersa, Port na h-aibhne lighthouse is built, the rocks here and for nine miles inland, are essentially different from those found throughout the island. They consist of highly metamorphosed stratified rocks, such as greenish-grey gneiss, pinkish-grey gneiss, with crystals of hornblende, quartzite, chlorite schist, bluish grey dolomite, which slightly effervesces when acted upon by dilute acid, serpentine, of a deep green colour interspersed with yellow crystals of various shades, and hypersthene interstratified, and dipping S.S.W. at an angle of 68°. These are pierced at frequent intervals by diorite dykes of considerable dimensions, for nine miles, and these pass inland at right angles to the plane of stratification. Although geographically associated with these rocks, they belong to a later geological period.

On the little island Oersa, we pass over the upturned edges of similar rocks. The gneiss has the same greenish-grey tinge, and is traversed by veins of a bright pink granitic variety, which graduates into a granular pinkish-grey. Along the precipitous face of the bold sea-cliffs, deep indentations have been made into the softer interstratified schist and junctions of the intrusive igneous rocks, by the erosive action of the Atlantic waves.

The dip and strike of the stratified rocks are much altered by the intrusive igneous rocks. The general dip, however, is to the S.S.W., until we reach Bruthac a' chladaich, near where the stratified rocks to the south-east all dip steadily to the S.E. The junction of the quartzite and calcareous deposits is marked by alternating beds or bands of the two rocks, showing at short intervals a repetition of previously existing conditions. Though marked in the outcrop as very distinct, they are nevertheless found on close inspection to present almost imperceptible gradations from one to the other.

Having thus briefly sketched the general characters and relations of these deposits, the question remains to be answered, Do they

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furnish us with sufficient evidence to warrant us in determining their age?

The sequence of the groups may be shortly described as follows:—

1. The sandstones which form the southern extent of the island, known as the Mull of Oa, and the schistose rocks which skirt the shore from Port Ellen, Kildalton, to Ard-tala bay, and for three miles inland, belong to the lower members of the lower Silurian period.

2. The quartzites which underly the schistose rocks, and of which the mountains on the east side of the island are built up, and which trend southwards with the underlying slates and calcareous deposits that fill up the centre of the island, are of Upper Cambrian age.

3. The deposits from Aird na h-abhann on the north to Baile Iochd-arach on the south, along the Sound of Islay, the conglomerates, the argillaceous deposits and dark quartzites found from Skerrols to the north of Islay House, and to the north-west, as far as Sanaig, are Lower Cambrian.

Although I have not seen the precise equivalents of those greenish-grey micaceous flags, with chocolate argillaceous partings, on the north side of Big Free-Port Bay, on which we find sun-cracks, rain prints, and what are sometimes supposed to be the tracks of annelids, they coincide well with similar rocks, defined as of Cambrian age by the late Sir R. Murchison, and which occur in Sutherlandshire, where their relation to an inferior conglomeritic mass is so clearly traced. Also with those described by the late Mr Salter and Dr Hicks, from the Longmynd beds in Wales. I think that it is almost unnecessary to adduce further facts. If similarity of physical conditions, and similarity of fossil forms are to guide us in determining the relations of formations, then those stratified rocks seen along the north-eastern side and centre of the island, folding over and surrounding the conglomerate mass, and that group near Sanaig should be placed in a similar stratigraphical position to those described by the above authors, thus extending the range of Cambrian rocks further south in the Highlands of Scotland than has been hitherto recorded.

Professor Ramsay suggests that probably the Cambrian argillaceous beds were deposited under fresh-water conditions. That they were deposited in an inland lake cannot be doubted,

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and that these cracks are due to the influence of the sun is abundantly evident. If they had been deposited in an estuary of the sea, the soft mud would not have got time to crack, as each inflowing tide would have kept the matrix sufficiently moist to prevent it from shrinking and cracking.

4. The metamorphic rocks on the western extremity of the island, and skirting the shore of Lochin-dàla for nine miles, and dipping S.S.W., are of Laurentian age. The limited time at my disposal did not enable me to give in detail a description of this interesting group. After the examination I did give them, I felt convinced that these crystalline stratified rocks belong to a very different period of time from those found in the central valley and south-eastern side of the island. There can therefore be little doubt regarding their proper identification; their lithological aspect and mineral characters coincide so well with the fundamental gneiss of Sutherlandshire, described by Sir R. Murchison, and designated by him as of Laurentian age. Indeed, on putting hand specimens of these rocks and rocks similar in crystallization, from the Outer Hebrides, *e.g.*, Harris, North Uist, Lewis, and from Sutherland on the mainland, into the hands of some of our ablest geologists, they all classified them as belonging to the same group. Although we have evidence highly suggestive, we are yet unprepared to speak with any degree of certainty regarding the source or direction of the materials constituting the basic conglomerate mass on the east side and north centre of the island. If, however, we glance at the topographical aspect of the Highlands and islands, and compare the boulders with the granites throughout the Highlands, we feel the necessity of tracing them to another source. And we hope we do not overstep the bounds of prudent speculation in suggesting that these erratics are the re-assorted materials of some great Northern Continent which has yielded to the ceaseless gnawing tooth of time, leaving those scattered fragments as the wreckage of its former greatness; and that the materials of which the mass is composed, have been transported by the agency of ice. The mineral characters of these boulders differ so widely from the granites at present found *in situ* throughout the Highlands, that a much higher antiquity for those found in Islay is suggested, while the finding of the glaciated rock at the base of the mass stamps their true character, and points to a period of time deeper than we have hitherto suspected;

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when glaciers and icebergs planed the hardest rocks, and transported matter, as they still do, obedient to one great law.

In conclusion, I may say that, had more time been at my disposal, I should have spoken more exhaustively upon some of the interesting geological phenomena of the island; yet, although imperfectly, I hope enough has been said to interest other observers with more leisure, and better fitted to do the subject the justice which it merits.

To Mr Ramsay of Kildalton, M.P., and to Mr Finlay of Losset, who kindly allowed me free passage over their estates, my thanks are due; as also to Mr James Scott, and to Mr Colin Hay, who frequently guided me to many of the points referred to. I am also much indebted to Mr Hector M'Lean, teacher, who gave me the proper readings of the Gaelic names mentioned in my paper.

XIV.—Geological Notes *on the* Cuttings in the City of Glasgow Union Railway between Bellgrove and Springburn. By James Neilson, jun.

[Read 13th May, 1875.]

The branch line connecting the College and Sighthill Stations of the North British Railway, was made principally to relieve the Queen Street terminus—long inadequate for the purpose—from the ever-increasing goods traffic. Although only about one mile and a half in length, its cost has been great, as besides heavy cuttings, with much building in and tunnelling, the Monkland Canal had to be diverted, and a new bed half a mile in length constructed.

Minerals have been long and extensively worked in the district. I remember a deserted coal pit and a sandstone quarry where the Camlachie goods station now stands, while another pit was till lately visible near the Cumbernauld Road, about 100 yards north of Duke Street. Craigpark whinstone quarry and Blochairn sand quarry are still being worked. Although, owing to the thick overlying deposits of clay, the locality has been so barren to the geologist as not to have been mentioned in the Transactions of the Society except in one instance, and then only to state that nothing of interest was to be seen, yet I do not know any place, where, within the space of a mile, there can be seen more

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interesting geological features,—igneous and stratified rocks, boulder clay, and other glacial deposits, besides numerous fossil remains. Unfortunately a number of the sections have been built up, but of those hereafter described, parts at Burnbank, Blochairn, and Garngad Road are still visible.

The first section worthy of note is one seen immediately after leaving the main line, where the Carboniferous rocks are cut for about 100 yards, Whitevale Street being about equidistant from either end. The section, which dips slightly S.W., is as follows:—

Sand.
Boulder Clay.
A* Sandy Shale.†
B Black Shale.
Coal.

The sandy shale and black shale are similar to those often met with in the upper coal measures, and contain numerous remains of plants, of which the following are most common:—*Calamites* (both perfect and crushed specimens, the former being found in the sandy shale standing upright, while the latter are lying horizontally), *Stigmaria*, *Neuropteris*, *Alethopteris*. The coal was only exposed for a day or two in the excavation for the foundation of a bridge; and I did not then see it, but observed it at the making of the other railway; it is about two feet thick. The position of these beds is without doubt near the top of the upper coal measures.

From this point the railway sweeps in one long curve, under Bluevale Street, East Miller Street, and Duke Street, (exactly under the site of the old Drygate toll, which has thus been improved out of existence); then along the course of the old Cumbernauld Road, which has now been diverted; and passing under this reaches the Alexandra Parade, where Carboniferous rocks are again exposed, as follows:—

	FT.	IN.
Shale, about	2	0
Soft Sandstone	6	0
Coal	2	3
Fireclay	3	6
Micaceous Sandstone, not cut through.		

The dip is about 1 in 6 to the south-east.

* Prefixed capital letters distinguish the fossiliferous beds. See the catalogue of fossils at the end of this Paper.

† Locally known as "Faikes."

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It will be observed that as the axis of the coal basin runs here nearly east and west, and we have been going at right angles to that direction, the natural rise in the strata would bring these beds from a much lower position than those at Whitevale. The "Virgin" coal was once wrought in this locality, and we may here be near its horizon. The sandstone, where seen, is rotted like that of Blochairn (to be after mentioned), and is of a white colour. No fossils were found here.

The next section is at the second bridge from this, close to Burnbank bleachfield, the dip being about 15° to the south-east.

		FT.	IN.
	Brown clay.		
	Boulder clay.		
	Black Shale, unfossiliferous?	2	0
C	Black feruginous shale, full of plant remains, in a bad state of preservation . . .	0	6
	Sandstone, in beds about 12 inches thick . .	6	0
D	Hard black shale, with *Anthracosia robusta* .	1	0
	Hard sandstone	0	7
	Whitish trap, interbedded	1	6
	Charred coal, columnar	0	8
	Fireclay, not cut through further than . .	6	0

A little further on we have—

		FT.	IN.
	Impure black sandstone or shale	0	6
E	Laminated sandstone, full of charred plant remains	2	0
	Black Shale, not cut through.		

These strata are still lower than the previous ones, and belong to the lower part of the upper coal measures, as is shown by the occurrence of the shell, *Anthracosia robusta*, which is only found from the horizon of the Drumgray coal downwards.*

It is very interesting to see the effect produced on the coal by the overlying bed of trap. The coal is perfectly charred, and is so hard at its junction with the trap as to strike fire; it is also changed from a stratified to a columnar condition, and specimens may be obtained here rivalling basaltic forms in regularity. This trap has probably come from the neighbouring boss of Craigpark, on part of which the Necropolis lies; and we find in one of the quarries there a charred coal similar to that found here. It has been supposed that a dike, emerging from Craig-

* See Trans. of Geol. Soc. Glas., Vol. iii., page 104.

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park, and running in an E. or N.E. direction, cuts off the upper coal measures, and dislocates the strata about 200 fathoms. It is said to be exposed in the hill running eastward from Cumbernauld Road, and also to run through Alexandra Park to the trap at Gartcraig. However that may be, we have no evidence of it here, and the various sections rather tell against the existence of a fault of anything like the extent above stated.

Passing onwards, we go under the new part of the Monkland Canal, and find ourselves in the cinder heap of Blochairn, where might have been seen a most interesting section of "recent igneous formation." The slag continued to burn for months after being turned out, and fused into large masses, which took a vast deal of work to cut through when the cutting was made. After we have gone through the tunnel we come to an interesting section, and of which, although the greater part is built up, there still remains enough to repay a visit. The strata belong to the Millstone grit series, which is somewhere about 300 fathoms below the "Ell" coal. The rocks exposed are sandstone, shale, fire-clay, anthracite coal, and three or four bands of clay ironstone; and the way in which they are uplifted and cut off is very instructive. At one place there is a dyke of white trap which, rising at an angle of about 60°, gradually becomes more attenuated and more horizontal, and disappears after assuming the character of a bedded trap, being, at its termination, only a few inches in thickness. At another place there is a flow of dark-coloured bedded trap; we find also several faults with no igneous rocks appearing.

At the end of this section lie the extensive quarries of Blochairn, where the sandstone is of a very soft nature—crumbling down on exposure to the atmosphere. The quickness with which it weathers is well shown in this cutting, as it is scooped out from two to three feet, leaving the hard overlying sandstone projecting above, although it has been exposed only a few months. The only fossils found here are some pyritized plant remains, which cannot be identified. On leaving these quarries, and passing under the bridge crossing the road leading to Blochairn, we come to a fresh set of sections which dip to the N. about ten or twelve degrees:—

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		FT.	IN.
	Thin-bedded sandstone	2	0
	Felspathic ash	1	6
	Shale	0	2
	Sandstone, containing many fragments of ash	0	6
F	Ash, with plant remains	0	6
F	Sandstones, thin-bedded, with plant remains	3	9
G	Do., do., with casts of marine shells	0	9
	Shale, arenaceous	1	6
G	Sandstone, with shells	1	6
G	Do., with casts of shells	2	6
	Sandstones, thin-bedded (say)	3	6
H	Black shale, with *Lingula*	0	9
	Sandstones, thin-bedded	3	0

This section disappears at what used to be the bed of the Molendinar Burn, and the next section almost immediately commences, dipping at about the same angle in an opposite direction, viz., S.E.; so that probably at this point the burn flows along a line of fault. The following section, which I believe to be simply a continuation of the foregoing, commences here:—

		FT.	IN.
	Sandstone, thin-bedded	1	9
G	Do., do., with casts of shells	0	9
	Kingle	2	6
J	Shale (calcareous)	1	0
I	Cement	1	1
J	Shale (not cut through) exposed about	6	0

It is remarkable that the sandstones here contain marine shells, which is an extremely rare occurrence. We find it stated by Mr Thos. Davidson, F.R.S., in his monograph of the "Carboniferous Brachiopoda of Scotland," that in 1857, at a cutting in Parliamentary Road, at the corner of Frederick Street, a sandstone was exposed containing numerous casts of *Productus*, *Spirifera*, etc.; and this, I believe, belongs to the above series, although the fossils seem to be different. It was impossible to keep separate the fossils belonging to each bed, as they were all thrown together into one heap, where I found the greater part of those I have collected. From the section, however, I find that *Orthis resupinata*, Martin, is common in all the beds, but especially so in one of them, where a single blow of the hammer sometimes revealed twenty or thirty specimens; another bed contains *Myalina Verneuilli* in abundance, and another, *Streptorhynchus crenistria*, var. *robusta*, Hall. This shell was first discovered in

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this country by Mr Jas. Thomson, F.G.S., in Tirfergus Glen, Campbeltown,* in an arenaceous deposit amongst strata, which he then believed to belong to the lower limestone series. Mr Thomson, however, now believes that this is the same as the Campbeltown horizon, which may thus be regarded as upper instead of lower limestone. The most noticeable shell found in this deposit is a specimen of *Discina*, which measures 1¾ inches in diameter, and which is referred to *D. Craigii*, Dav., by Mr Davidson. In those beds where we find only casts, the space occupied by the shell is left vacant, and the muscular impressions are shown on the internal cast. The bed containing the shells is a hard sandstone, and few good specimens were obtained from it. There is also a kind of sandstone about 6 inches thick, containing numerous specimens of *Myalina Verneuilli*, M'Coy, in an uncrushed state; it was reached during the excavation for a culvert to carry off the Molendinar Burn, and was only exposed for a few days, so that I did not get its proper position.

The shale above the cement is charged with fossils, generally in a bad state of preservation, and all changed into cement stone. Some very fine examples of various shells, and some very rare species have been found here; among which may be mentioned *Pleurotomaria striata, Nautilus nodiferus, Myacites sulcatus* (covered with little points arranged in straight lines radiating from the hinge); *Dentalium inornatum* is also abundant, and somewhat different from those found in other places, being longer and not having so much taper. The shell which will attract the most attention, however, is a *Productus*, believed by Mr Davidson to be *P. carbonarius*, of de Koninck. Mr Davidson figured a specimen (belonging to the Jermyn Street Museum, London, and said to be from a locality north of Glasgow) in his monograph of Scottish Carboniferous Brachiopoda, and afterwards in his monograph of British Carboniferous Brachiopoda, being the only British specimen he had ever seen. Four specimens were sent him for identification from this bed.†

In the Catalogue of Carboniferous Fossils of the West of Scotland‡ it is altogether omitted, and in the Catalogue of the

* Trans. Geol. Soc. Glas., Vol. ii., page 76.

† Prof. de Koninck, who has since seen these fossils, pronounces them to be *P. carbonarius*.

‡ Trans. Geol. Soc. Glas., Vol. iii., 1871.

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Western Scottish Fossils* it is noted as "said to be from the Glasgow coalfield." It would be interesting to know the mineral character of the specimen in the Jermyn Street Museum, as we could thereby fix with tolerable certainty if this is the bed from which it came. It would be curious if this should now prove to be the case, and that it should not have been decided for twenty years after the publication of Mr Davidson's monographs. *P. pustulosus*, Philips, which had not at that time been got in Scotland, is figured from the same locality; and we also find in this bed specimens which would have been referred to this species, but that there were found all varieties between it and the typical *P. scabriculus*, Mart., to which they have been referred, although some of the specimens show the median ridge of the interior of the dorsal valve to be simple, as in *P. pustulosus*. This shale contains numerous nodules full of shells; and we have noticed that a number of shells occur in these which are not found in the shale. The shale underlying the limestone contains fewer fossils, but these are, so far as I have seen, the same as in the upper shale; for the same reason as in the case of the sandstones, I cannot separate the fossils in the two beds.

The cement is too "cold" for profitable working. It is an extremely hard stone at first, but on exposure becomes changed into a very soft ochre. Its structure is altered in a remarkable degree from a stratified to a columnar rock. In that part of the section, where Garngad Road used to be, we have the cement coming to the surface, and for about twenty feet or so it presents this columnar structure, which gradually dies out as the strata get more covered from the weather. I have never heard of columnar structure being produced by any other than igneous action, but here is an example caused in quite another way. The columns are generally four sided, and from two to four inches across. The cement contains numerous fossils, which are very difficult to extract.

Proceeding onward across Garngad Road, we find the cutting is light, and some shale is seen, but nothing worthy of remark till we come to the tunnel under the Caledonian Railway, where we find a section like the following:—

* Published by the local Executive Committee of the British Association, Glasgow, 1876.

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	FT.	IN.
Sandstone	10	0
Sandy shale	1	6
Coal	0	9

These lie at an angle of about 45° against a fault, on the other side of which we find

	FT.	IN.
Sandy shale	2	0

Dark brown sandstone (not cut through).

This sandstone is very dark coloured, and extends a good way into the tunnel. On the north side of the tunnel there is a quarry, in which we find a fine white sandstone overlaid by about twenty feet of coarse rock. From this point the railway is on level ground, and shortly afterwards joins the older branch near Sighthill.

With regard to the glacial deposits, we have the blue boulder clay, containing the usual quantity of boulders, some as large as six feet on the longer axis. It covers the whole district towards the south of this line, and may be seen here from Whitevale as far as Burnbank; but, so far as shown by the cuttings north of this, the district is remarkably clear of it. Most of the boulders are local; thus we find at Whitevale and elsewhere fragments of the burnt coal and ash *in situ* at Burnbank, and of the cement at Garngad Road. There are very few far-travelled stones; however, we managed to pick up specimens of gneiss and schist, which have come probably from the West Highlands. A black fine-grained limestone is common, but I cannot say whence it is derived. Various boulders contained fossils, and one dark very heavy sulphurous limestone appeared to be almost entirely made up of shells; while in another block were found *Spirifera*, *Terebratula*, etc. One block of sandstone, on the Garngad Hill near the railway, disclosed a specimen of *Stigmaria stellata*. But the most interesting boulder was one of blue limestone, which, on being weathered, became of a dark cream-colour, and softened so that, from the crushed fragments, about twenty minute species of spiral shells were taken, as well as various Entomostraca.

Lying in a hollow of the boulder clay, near Whitevale, was a patch of sand about six feet thick. Laminated clay is also found, extending from Duke Street for a few hundred yards to the north, the boulder clay being abruptly cut off, as it were, so that the bridge over Duke Street has to the south a thick bed of blue clay, and to the north a similar bed of brick clay.

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At the heavy cutting north of Alexandria Parade we find, on the top of the true boulder clay, another boulder clay, which differs from it in being of a brown or rusty colour, and having an appearance as if it had been partially stratified, and that in a wavy manner. The contained boulders are not so large, although quite as numerous as in the true clay, and a number of them are striated. I would suggest that this bed may have been formed from material dropped from floating ice into moving water, and that it accumulated faster than it could be arranged by the current.

I have not observed any polished or striated rock surfaces, though the great majority of the boulders are so; a curious circumstance is the manner in which coal is placed in the till, in several places being collected as in a seam. In one of these it rises at about an angle of 45° for seven or eight feet, and turning with a sharp anticline descends at about the same angle, thus forming two sides of a triangle with a right angle at the apex, it has a thickness of about thirty inches. At another place this drift coal is seen deposited in a curve, the upper end of which is nearly perpendicular and about eighteen inches thick. From this point it becomes thinner and ceases about six feet lower, with a thickness of about six inches. On examining the mass we find it composed of fine dross, the largest of the grains being about the size of a large pea. I cannot give any satisfactory cause for this deposit.

The following is a list of the fossils found in the various strata above noted. My thanks are due to Mr Joseph Wright, Belfast, for help in naming the Aviculopectens, and to Mr R. Etheridge, jun., of H.M. Geological Survey, Edinburgh, for assistance in naming a number of the fossils :—

NOTE OF THE FOSSILIFEROUS BEDS.

Mark.	Locality.	Character.	Prevailing Fossils.
A	Whitevale.	Sandy shale.	Plants.
B	Whitevale.	Black shale.	Plants.
C	Burnbank.	Black feruginous shale.	Plants.
D	Burnbank.	Hard black shale.	Shells.
E	Burnbank.	Laminated sandstone.	Plants.
F	South of Garngad Road.	Volcanic ash and sandstone.	Plants.
G	South of Garngad Road.	Various beds of sandstone.	Marine shells.
H	South of Garngad Road.	Black shale.	Lingula.
I	Garngad Road.	Calcareous shale and cement.	Marine shells.

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PLANTÆ.

Plant remains are found more or less in all the beds, except in the cement, and the shales overlying and underlying it. In many of them, however, the remains are charred, and defy determination.

ALGÆ.

Remains of what is believed to be a fucoid occur abundantly in the partings of some of the sandstones to the south of Garngad Road.

FILICES.

Alethopteris heterophyllia, Lindley.	A B	Common.
——— *lonchitidis*, Sternberg.	A B	Common.
——— *serra ?*, Lindl.	A	Very rare.
Cyclopteris, sp.	B	Very rare.
Neuropteris gigantea, Sternb.	B	Common.
——— *Loshii*, Brongniart.	B	Common.
——— *attenuata*, Lindl.	B	Rare.
Sphenopteris latifolia, Brongn.	B	Rare.

EQUISETACEÆ.

Calamites approximatus, Brongn.	A	Common.
——— *cannæformis*, Schlotheim.	B	Rare.
——— *nodosus*, Schloth.	A B E	Common.

LYCOPODIACEÆ.

Halonia, sp.	B	Rare.
Knorria taxina, Lindl.	C	Common.
Lepidodendron elegans, Brongn.	C	Common.
——— *gracile*, Lindl.	C	Common.
——— *sp.*	A	Rare.
Stigmaria ficoides, Brongn.	A B F	Common.
Sigillaria, sp.		Quarry north of Cal. Railway.
Cardiocarpon, sp.	F	Very rare.

ACTINOZOA.

Alveolites septosa, Fleming.	I	One on a *Nautilus*.
Clisiophyllum bipartitum ?, M'Coy.	G	One specimen (cast).

ECHINODERMATA.

Pisocrinus globularis, De Koninck.	I	Moderately common.
Poteriocrinus crassus, Miller.	G I	Rare.
——— *quinquangularis*, Miller.	G I	Common.
——— *tenuis*, Miller.	G I	Common.

ANNELIDA.

Serpulites carbonarius, M'Coy.	G	Common in one of the sandstones.

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CRUSTACEA.

Owing to the hard nature of the shale marked I, it has not been searched for Ostracoda, but without doubt they are to be found in it. Should it be allowed to weather, it may be possible at some future time to add a list of the species found.

TRILOBITA.

Griffithides mesotuberculatus, M'Coy.	I	Rare.

BRACHIOPODA.

Athyris ambigua, Sowerby.	I	Common.
Discina Craigii, Davidson.	G	One spec. 1¾ in. diam.
——— *nitida*, Phillips.	G I	Rare.
Lingula mytiloides, Sow.	I	Common.
——— *squamiformis*, Phill.	G	Common.
Orthis resupinata, Martin.	G I	Abundant.
Productus aculeatus, Mart.	I	Very rare, in nodules.
——— *carbonarius*, De Kon.	I	Not rare.
——— *costatus*, var. *muricatus*, Phill.	G	Rare; I Common.
——— *longispinus*, Sow.	I	Not rare.
——— *scabriculus*, Phill.	G	Rare; I Common.
——— *semireticulatus*, var. *Martini*, Sow.	I	Rare.
——— *sinuatus*, De Kon.	I	Common.
Spirifera trigonalis, Mart.	I	Common.
——— *Urei*, Flem.	I	Very rare.
Spiriferina cristata, var. *octoplicata*, Sow.	I	Rare.
Streptorhynchus crenistria, Phill.	G I	Common.
——— var. *radialis*, Phill.	I	Common.
——— var. *robusta*, Hall.	G	Abundant; I Rare.

LAMELLIBRANCHIATA.

With the exception of one species (*Anthracosia robusta*), these are all confined to the beds marked G and I. There are besides those named probably two or three species of *Aviculopecten* undescribed, and perhaps one or two shells belonging to the Dimyaria are new.

A number of these also could not be identified, owing to their imperfect state of preservation.

MONOMYARIA.

Avicula alternata, M'Coy.	I	Rare; in nodules.
Aviculopecten arenosus, Phill.	I	Common in nodules.
——— *cælatus*, M'Coy.	I	Common.
——— *granosus*, Phill.	I	Very rare.
——— *Murchisoni*, M'Coy.	I	Rare.
——— *sp.*	G	Rare.
——— *2 sp?*	I	Rare.
Posidonomya corrugata, Etheridge.	I	Very rare.
Pinna flabelliformis, Mart.	I	Very rare.

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DIMYARIA.

Anthracosia robusta, Sow.	D	Common.
Arca, 2 sp.	G I	Rare.
Cardiomorpha oblonga, Sow.	I	Rare.
Cypricardia rhombea, Phill.	I	Common.
——— *sinuata*, M'Coy.	I	Very rare.
Edmondia gibbosa, M'Coy.	I	Moderately common.
Leda attenuata, Flem.	I	Common.
—— *intermedia*, Ether.	I	Common.
—— *longirostris*, M'Coy.	I	Rare.
—— *oblonga*, M'Coy.	I	Rare.
Leptodomus costellatus ?, M'Coy.	I	Rare.
Lutraria elongata ?, M'Coy.	I	Not rare.
Modiola megaloba, M'Coy.	I	Rare.
Myalina Verneuilli, M'Coy.		
Myacites sulcata, Flem.	I	Common & very fine.
Nucula gibbosa, Flem.	I	Common.
——— *sp.*	I	Not rare.
Pandora ? clavata, M'Coy.	I	Common.

GASTEROPODA.

Dentalium inornatum ?, M'Coy.	I	Abundant.
Macrocheilus acutus, Sow.	I	Rare.
——— *fusiformis*, Sow.	G	Rare.
——— *imbricatus*, Sow.	I	Moderately common.
——— *Michotianus*, Sow.	I	Rare.
——— *sp.*	I	Abundant.
Murchisonia quadricarinata, M'Coy.	I	Rare.
——— *striatula*, De Kon.	I	Common.
Naticopsis elliptica, Phill.	I	Rare.
——— *elongata*, Phill.	I	Rare.
——— *variata*, Phill.	I	Common.
Pleurotomaria Frenoyana, De Kon.	I	Very rare.
——— *striata*, Sow.	I	Rare.

HETEROPODA.

Bellerophon decussatus, Flem.; Large and fine.	I	Common.
——— var. *striatus*, Flem.; Large and fine.	I	Common.
——— *Dumontii*, D'Orbigny.	G I	Rare.
——— *Leveilleanus*, De Kon.	G	Very rare.
——— *Urei*, Flem.; Large and fine.	I	Common.

CEPHALOPODA.

These are very rare, except *Nautilus nodiferus*, Armstrong, common in fragments. I have, however, found two nearly whole specimens, but a little crushed.

Actinoceras gyganteum, Sow.	I	Very rare.
Goniatites excavatus ?, Phill.	I	Two fragments.
——— *mutabilis ?*, Phill.	I	One specimen.

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Goniatites sp.	G	Rare.
Nautilus nodiferus, Armstrong.	I	Common.
——— *quadratus*, Flem.	G	Rare.
——— ——— ———	I	Moderately common.
Orthoceras attenuatum, Flem.	G	One specimen.

PISCES.

Cochliodus magnus, Agassiz.	G	One tooth.
Rhizodopsis granulatus, Ag.	I	Very rare.

[ABSTRACT.]

XV.—NOTES *on* GLACIAL MOUNDS *near* BALQUHIDDER, PERTHSHIRE. By DUGALD BELL.

[Read 12th November, 1874.]

IN this Paper the author described some remarkable glacial mounds which occur in the neighbourhood of Balquhidder, Perthshire. They had attracted his attention when passing through the district several years ago, and more recently he had had an opportunity of looking at them again. The locality, as the members were aware, is on the line of railway between Callander and Killin. Proceeding from the Bridge of Allan to Callander, we cross the great belt of the old red sandstone of Scotland, deeply covered in many places with till and "upper drift," and strewn here and there with erratics, some of considerable size. Near Callander we come upon the conglomerate at the base of the system, which extends north-east by Crieff and Dunkeld, and south-west by Aberfoyle, and through Loch Lomond to the Firth of Clyde. Here we observe some well-marked instances of striation. Leaving Callander, we enter the schistose region at the Pass of Leny; and as we pass along the shores of Loch Lubnaig, we see striking examples of ice-work on the hill sides and along the bottom of the valley. From Callander our course has been nearly due north, but at Kingshouse the upper part of Strathyre bends sharply round to the west, extending about two miles in that direction to Balquhidder, at the foot of Loch Voil. This beautiful, lonely lake stretches some four or five miles further west towards the lofty range of mountains, several of them about 3000 feet in height, which forms the watershed between it and Glen Falloch. At Kingshouse, where we leave the railway, the

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mounds now referred to present themselves in a very striking form. They are heaped up against the hill at Kingshouse, facing the upper part of the strath, and extend for some distance also towards Lochearnhead, indicating that the ice, which at one time filled the valley, diverged at this rather sudden turn in two opposite directions, the greater part of it, however, sweeping round towards the south, in the direction of Loch Lubnaig and Callander. Having illustrated this by a few sketches, and by a reference to corresponding phenomena which he had lately observed in Switzerland, Mr Bell next called attention to another series of mounds presenting similar features, which occur in the "side glen" called "Glen Buckie," or the Calair Burn, that opens out southward from Balquhidder, and leads on to Glenfinlas in the Trossachs. Near the mouth of this glen there is a very wonderful display of heaps and ridges of moraine matter, extending to a considerable height on the hill-sides, and which are roughened over with an immense number of perched blocks, some of large size. Among the varieties of rock observed here is a peculiarly hard dark-grained syenite, boulders of which have been found in the neighbourhood of Doune on the one side, and of Dumbarton on the other. The arrangement of these mounds and ridges clearly indicates a curving of the ice to the east, round the shoulder of the hill called Buchaille Bhreige, to coalesce with the main mass proceeding from the mountains at the head of Loch Voil. On the opposite side of the strath there is another and smaller "side glen," Kirkton Glen, extending to the north, which presents similar phenomena, though not on so striking a scale. In crossing into this glen from Luib, at the date of his earlier visit, the writer had seen reason to believe that at one time the ice had passed into it from Glen Dochart on the north; and as the summit level between the two is close upon 2000 feet, this may give some idea of the magnitude of the glacier which then occupied Glen Dochart from side to side, and extended eastward over what is now the bed of Loch Tay. The mounds, however, at Kingshouse and Calair Burn, which he had brought under the notice of the Society, belonged to a later stage of the glacial period, when the great *mer de glace* had given place to local glaciers, of whose latest work these were the indications. They occur at Kingshouse at about 450 feet and upwards, and at Calair Burn chiefly between 500 and 700 feet above the sea-level, and had

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evidently never been touched by the sea since they were laid down. Mr. Bell then referred to some points connected with the silting up of lakes, as presented by Loch Lubnaig and Loch Voil, which were once in all probability united; and concluded by recommending those members who were interested in such subjects to visit the picturesque locality which he had, however imperfectly, brought under their notice.

[ABSTRACT.]

XVI.—ON THE GEOLOGY *of* SWITZERLAND. By DUGALD BELL.

[Read 14th January, 1875.]

IN these Notes on the Geology of Switzerland, the author embodied some observations made during a recent visit to that country. After remarking on the connection that exists between the scenery and the geology of a country, he alluded to the many eminent investigators who had illustrated the rock-formations of Switzerland—as Studer, Escher, E. de Beaumont, Favre, Desor, on the Continent, with Murchison, Lyell, Ramsay, and others of the English school. There also Charpentier, Rendu, Guyot, Agassiz, Forbes, and Tyndall had spent laborious but delightful days in studying the structure and action of glaciers. The "playground of Europe" had thus become classic ground to the geologist. He then gave an outline of the general structure of the country, in its three main divisions of the Jura mountains, the middle plain, and the Alpine districts, showing how the secondary rocks—oolitic and chalk—of the Jura are overlaid by tertiary strata (*Molasse*) in the middle plain, but reappear on the flanks of the Alps upheaved into lofty mountains, and are succeeded by mica-schist, gneiss, and granite, forming the central parts of the great Alpine chain and the back-bone of the European continent. The first point, accordingly, which struck one with regard to Swiss geology, was the comparatively recent age of these the loftiest mountains in Europe, composed as they are in great part of strata formed within the tertiary period. While our own higher mountains are made up of rocks belonging to an immense antiquity, the Alps, the Apennines, Pyrenees, Carpathians, in Europe, and the

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Himalayas in Asia, are all, geologically—as shown by the strata which they contain—of very modern date. This led him to notice the contrast presented by the comparatively undisturbed state of those secondary and tertiary deposits in Britain, with the prodigious upheavals and disruptions which the same strata have undergone on the Continent. Not that this country was entirely exempt from these disturbances of the earth's crust, which appear to have prevailed in Switzerland during part of the tertiary period. The researches of the Duke of Argyll, of Prof. Geikie, and, more recently, of Prof. Judd, have established the former existence along the north-western coast of the British Islands of a great chain of volcanoes, which threw out immense sheets of lava and heaps of scoria subsequent to the middle of the tertiary period; and these great Hebridean volcanoes appear to have been contemporaneous with the final elevation of the Alpine chain. The next point to which Mr Bell referred was the astonishing metamorphism which the secondary strata in or near the Alps had undergone. To find belemnites in mica-schist must be a new experience to a student of the science from this side of the Channel. Yet in some places in the Alps the lias and other Jurassic rocks had been completely altered into clayslates, mica-schists, and gneiss, with bands of crystalline limestone. Elsewhere, even tertiary strata, nummulitic limestone, etc., had been converted into crystalline rocks—into marble, quartz rock, and gneiss; so that geologists were now disposed to conclude that not only the schistose rocks, but also the granites, as those of St Gothard and Mont Blanc, are of metamorphic origin, and that, in short, the main mass of the Swiss Alps is composed of altered secondary rocks. He then gave a graphic sketch of the route from Lucerne, by the St Gothard and Furca Passes, to the Rhone Glacier, and thence by Grimsel and the Hasli Thal, through the well-known Bernese Oberland. He described at some length the Rhone and Unteraar Glaciers, and the evidences of their vast extension in former times, paying a hearty tribute to the memory of Agassiz and other early investigators of these phenomena. With regard to boulder clay, of which some doubted the existence in Switzerland, he instanced the old moraines of the Rhone Glacier, and the ridges with abundance of fine clay found close to the end of the existing glacier, as very similar to the boulder clay of this country. At the same time, it was to be remembered that the nature of the boulder clay in any given

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place must depend on the rocks over which the glacier had passed. It was not to be expected that a glacier proceeding only from granite or gneiss should produce a clay in all respects the same as that formed by one which had passed over a great variety of rocks, slates, old red sandstone, traps, and beds belonging to the coal formation. Besides, it was not close to the small existing glaciers that the old typical boulder clay of Switzerland was to be looked for, but in the lower valleys, on the central plain, and even at the base of the Jura mountains opposite. He gave instances of its occurrence in such situations—which had also been noticed by M. Morlot, Sir Chas. Lyell, and Mr James Geikie—pointing out that as there was no reason to suppose that Switzerland had been submerged during the glacial epoch or since, these were clear proofs of the formation of till or boulder clay by the action of land ice alone. He concluded by referring to the enormous waste and wearing down of the rocks caused by these icy masses, as evidenced by the quantities of sediment which every glacier stream or river is carrying away, and which, with the other meteoric agencies, are surely, and by no means slowly, bringing down these majestic mountains, and spreading out their materials elsewhere.

XVII.—Geological Climate. By Sir William Thomson, LL.D., F.R.S., etc., President. With a Map.

[Read 22d February, 1877.]

The subject on which I am to speak to you this evening, is one which has interested and exercised geologists from the very beginning of their science. We find in geological strata many evidences of differences of climate through different periods of past time; and strenuous endeavours have been made to account for those differences. The subject has acquired a special interest within the last few months, through the return of the Arctic expedition bringing evidences of a very warm climate, probably as warm as we have it now in the tropics, within nine degrees of the North Pole. It had been well known that places far north as for instance Melville Island and Prince Patrick's Island, within fifteen degrees of the pole, had at some time, not very remote, enjoyed a climate comparable with our own or at

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all events comparable with the climates of Norway, Sweden, and the north of Scotland. On this point I find a most interesting statement in Croll's book, "Climate and Time." Although it is no doubt well known to many present I am sure all will hear it with interest if I read it to you. It is entitled "Evidence of Warm Periods in Arctic Regions."—"The fact that stumps, etc., of full-grown trees have been found in places where at present nothing is to be met with but fields of snow and ice, and where the mean annual temperature scarcely rises above the zero of the Fahrenheit Thermometer, is good evidence to show that the climate of the arctic regions was once much warmer than now. The remains of an ancient forest were discovered by Captain M'Clure, in Banks's Land, in latitude 74° 48′. He found a great accumulation of trees, from the sea level to an elevation of upwards of 300 feet. 'I entered a ravine,' says Captain M'Clure, 'some miles inland, and found the north side of it, for a depth of 40 feet from the surface, composed of one mass of wood similar to what I had before seen.'* In the ravine he observed a tree protruding about 8 feet, and 3 feet in circumference. And he further states that, '*From the perfect state of the bark*, and the position of the trees so far from the sea, there can be but little doubt that they grew originally in the country.' A cone of one of the fir-trees was brought home, and was found to belong apparently to the genus *Abies*, resembling *A.* (*Pinus*) *alba*.

"In Prince Patrick's Island, in latitude 76° 12′ N., longitude 122° W., near the head of Walker Inlet, and a considerable distance in the interior in one of the ravines, a tree, protruding about 10 feet from the bank was discovered by Lieutenant Mecham. It proved to be 4 feet in circumference. In its neighbourhood several others were seen, all of them similar to some he had found at Cape Manning; each of them measured 4 feet round and 30 feet in length. The carpenter stated that the trees resembled larch. Lieutenant Mecham, from their appearance and position, concluded that they must have grown in the country.†

"Trees under similar conditions were also found by Lieutenant Pim on Prince Patrick's Island, and by Captain Parry on Melville

* "Discovery of the North-West Passage," page 213.

† "Voyage of the Resolute," page 294.

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Island, all considerably above the present sea-level and at a distance from the shore. On the coast of New Siberia, Lieutenant Anjou found a cliff of clay containing stems of trees still capable of being used for fuel.

"'This remarkable phenomenon,' says Captain Osborne, 'opens a vast field for conjecture, and the imagination becomes bewildered in trying to realise that period of the world's history when the absence of ice and a milder climate allowed forest trees to grow in a region where now the ground-willow and the dwarf-birch have to struggle for existence.'

"Sir Roderick Murchison came to the conclusion that all those trees were drifted to their present position when the islands of the Arctic Archipelago were submerged." * * * * "As Captain Osborne has pointed out, however, Sir Roderick's hypothesis leaves the real difficulty untouched. 'A very different climate,' he says, 'must then have existed in those regions to allow driftwood so perfect as to retain its bark to reach such great distances; and perhaps it may be argued that if that sea was sufficiently clear of ice to allow such timber to drift unscathed to Prince Patrick's Land, *that that very absence of a frozen sea would allow fir trees to grow in a soil naturally fertile.*' †

* * * "All who have seen those trees in arctic regions agree in thinking that they grew *in situ.* And Professor Haughton, in his excellent account of the arctic archipelago appended to M'Clintock's 'Narrative of Arctic Discoveries,' after a careful examination of the entire evidence on the subject, is distinctly of the same opinion; while the recent researches of Professor Heer put it beyond doubt that the drift theory must be abandoned.

"Undoubtedly the arctic archipelago was submerged to an extent that could have admitted of those trees being floated to their present positions;" * * * "but submergence, without a warmer condition of climate, would not enable trees to reach those regions with their bark entire.

"But in reality we are not left to theorise on the subject, for we have a well-authenticated case of one of those trees being got by Captain Belcher standing erect in the position in which

* Quarterly Journal Geological Society, Vol. XI., page 540.

† "M'Clure's North West Passage," page 214. Second Edition.

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it grew. It was found immediately to the northward of the narrow strait opening into Wellington Sound, in latitude 75° 32′ N., longitude 92° W., and about a mile and a half inland. The tree was dug up out of the frozen ground, and along with it a portion of the soil which was immediately in contact with the roots. The whole was packed in canvas and brought to England. Near to the spot several knolls of peat mosses about nine inches in depth were found, containing the bones of the lemming in great numbers. The tree in question was examined by Sir William Hooker, who gave the following report concerning it, which bears out strongly the fact of its having grown *in situ*.

"'The piece of wood brought by Sir Edward Belcher from the shores of Wellington Channel belongs to a species of pine probably the *Pinus* (*Abies*) *alba*, the most northern conifer. The structure of the wood of the specimen brought home differs remarkably in its anatomical character from that of any other conifer with which I am acquainted. Each concentric ring (or annual growth) consists of two zones of tissue; one, the outer, that towards the circumference, is broader, of a pale colour, and consists of ordinary tubes of fibres of wood, marked with discs common to all coniferæ. These discs are usually opposite one another when more than one row of them occur in the direction of the length of the fibre; and, what is very unusual, present radiating lines from the central depression to the circumference. Secondly, the inner zone of each annual ring of wood is narrower, of a dark colour, and formed of more slender woody fibres, with thicker walls in proportion to their diameter. These tubes have few or no discs upon them but are covered with spiral striæ, giving the appearance of each tube being formed of a twisted band. The above characters prevail in all parts of the wood, but are slightly modified in different rings. Thus the outer zone is broader in some than in others, the disc bearing fibres of the outer zone are sometimes faintly marked with spiral striæ; and the spirally marked fibres of the inner zone sometimes bear discs. These appearances suggest the annual recurrence of some special cause that shall thus modify the first and last formed fibres of each year's deposit, so that that first formed may differ in amount as well as in kind from that last formed; and the peculiar conditions of an

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arctic climate appear to afford an adequate solution. The inner or first-formed zone, must be regarded as imperfectly developed, being deposited at a season when the functions of the plant are very intermittently exercised, and when a few short hours of sunshine are daily succeeded by many of extreme cold. As the season advances the sun's heat and light are continuous during the greater part of the twenty four hours, and the newly formed wood fibres are hence more perfectly developed, they are much longer, present no signs of striæ, but are studded with discs of a more highly organized structure than are usual in the natural order to which this tree belongs.' *

"Another circumstance which shows that the tree had grown where it was found is the fact that in digging up the roots portions of the leaves were obtained. It may also be mentioned that near this place was found an old river channel cut deeply into the rock, which, at some remote period, when the climate must have been less rigorous than at present, had been occupied by a river of considerable size.

"Now, it is evident that if a tree could have grown at Wellington Sound, there is no reason why one might not have grown at Banks's Land, or at Prince Patrick's Island. And, if the climatic condition of the country would allow one tree to grow, it would equally as well allow a hundred, a thousand, or a whole forest. If this, then, be the case, Sir Roderick's objection to the theory of growth *in situ* falls to the ground."

The theory set forth by Lyell in the celebrated twelfth chapter of his "Principles of Geology," according to which variations of climate are explained by variations in the distribution of land and sea, seems amply sufficient to account for forests of such trees as now flourish in northern Europe having grown over those already explored arctic islands on the north side of north America where we have found their remains, and to lead us to expect that similar remains of ancient forests may be found anywhere within the arctic circle where land is reached and explored in future, even if up to the very North Pole. Just look at this map of the circumpolar regions. Look at this great north polar Mediterranean sea, everywhere about 2000 miles across. At present there is just one *wide* entrance to it

* "British Association Report for 1855," p. 381. "The Last of the Arctic Voyages," vol. i., p. 381.

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Land above 2000 feet in elevati

Snow fields & Glaciers

Barren Tundra lands

Region of Northern forests

Political boundaries

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from temperate waters, that "Greenland sea," a channel 720 miles broad between Norway and East Greenland opening the Polar Sea to the North Atlantic. On the west side of Greenland, between it on the east and Ellesmere Land and Grinnel Land on the west, there is another entrance—the long narrow channel of Smith's Sound, Kennedy Channel, and Robeson Channel, 600 miles long, narrowing to about 30 miles in several places, and to 20 miles in the very portal of the Polar sea at the north end of Robeson Channel. There are besides entrances by long intricate, narrow channels among the islands of the North American Archipelago west of Ellesmere Land and Grinnel Land: and just one other entrance—that from the North Pacific,—Behring's Strait fifty miles broad. Travel now along the boundary of the North Polar Sea eastwards; first along the north coast of Europe and Asia, from Norway round to Cape North in the far east of Siberia; thence on eastwards in west longitude along the north coast of the extreme eastern peninsula of Siberia; then across Behring's Strait along the north coast of the North American continent to Mackenzie River and Franklin Bay: then northwards and westwards along the eastern and northern coasts of the outlying islands of that great north American Archipelago so splendidly explored by British Arctic expeditions within the last 60 years: then from Parry Islands and Queen's Channel and Belcher Channel strike northwards and explore 300 miles of unknown but probably existing east and north east coasts of Ellesmere Land and Grinnel land till you come to Cape Alfred Ernest and Point Alert. Travelling thence eastwards on Lieut. Aldrich's sledge route of 225 miles along the North coast of Grinnel Land, you find yourself once more among familiar names;* Cape Evans, Milne Bay, North west Cape May, Cape Richards, Cape Stephenson, Cape Alexandra, Ward Hunt Island, Disraeli Bay, Cape Albert Edward, Cape Nares, Cape Aldrich, Parr Bay, Clements Markham Inlet, Feilden Peninsula, Cape Joseph Henry, Paterson Bay, Hilgard Bay, Cape Belknap; till you come to the Alert's winter quarters of 1875–6. Then strike across the mouth of Robeson Channel 20 miles and you find 120 miles of the

* These names are all to be found in the large-scale charts of the Admiralty Blue Book containing the full report of the recent Arctic Expedition.

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North coast of Greenland, well surveyed by Lieut. Beaumont. Beyond the end of his sledge route there are notable features, Mount Farragut, Mount Coppinger, North-east Cape May, Mount Hooker, Beaumont Island, with its Mount Albert; and at a distance of 30 miles Cape Britannia; all sketched and their positions accurately fixed by "angles." Lithographed views of them are published in the Admiralty Blue-book, so that you will recognize them when you see them, as readily and surely as a stranger entering the British Channel can recognize St. Michael's Mount, or the Lizard, or Rame Head, or Portland, or Bolt Head, or the Isle of Wight. From Cape Britannia you have 500 miles of unknown but probably existing north and north-east coast line of Greenland to travel over till you find yourself at Cape Bismark: thence a few miles south and you may rest in Ardencaple Inlet having completed your 6300 miles journey round the whole coast of the Arctic sea. But that unexplored 300 miles of Ellesmere Land and Grinnel Land from Belcher Channel to Cape Alfred Ernest, and that 500 miles of North and East Greenland! Surely Austria, Germany, America, and England will continue their great work of Arctic exploration: and may we not hope that happier times will soon come, when France and Russia will join in the amicable rivalry—not for the mere object, or perhaps not at all for the object, of reaching the north pole, but to explore the still unexplored 800 miles of coast line of the Arctic Sea, to find how far west and north Kellet's Land extends, and to discover all that can be discovered of the Austrian Islands north east of Spitzbergen.

Now look once more at the arctic chart, and imagine the circumpolar land to be one or two thousand feet lower relatively to the sea level than at present. Such an effort of imagination does not take away your breath. You are well trained for it by the succession of elevations and subsidences which you have been called on to admit for explanation of the familiar features of our Scottish hills and glens. A thousand feet of depression would submerge the continents of Europe, Asia, and America, for thousands of miles from their present northern coast lines; and would give instead of the present land-locked and therefore ice-bound Arctic sea, an open iceless ocean, with only a number of small steep islands to obstruct the free interchange of water

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between the North Pole and temperate or tropical regions. That the arctic sea would, in such circumstances, be free from ice quite up to the north pole may be I think securely inferred from what, in the present condition of the globe, we know of ice bound and open seas in the northern hemisphere and of the southern ocean abounding in icebergs but probably nowhere ice-bound up to the very coast of the circumpolar Antarctic continent, except in more or less land-locked bays. We can scarcely doubt, from what we actually see, that if that Antarctic continent were not there to receive snow (or hoar frost) to let it be kneaded into ice-sheet and glaciers, and to deliver masses of ice to be broken and washed away from its coasts, there would be neither ice nor icebergs in the southern hemisphere. Frozen seas, and icebergs in open seas, could not exist without land or very shallow water, in polar regions. Suppose sun and seasons, and climate, and distribution of sea and land to be all just as they are but with this difference that the Antarctic fixed ice be not supported by land above the sea level as it is, but be aground on solid earth everywhere 100 fathoms below the sea level. The undermining influence of the water washing against the ice all round would certainly cause more of icebergs to break away from it than at present: its area would therefore diminish (for it does not increase at present). The smaller the area of ice round the pole, the more rapidly must its boundary be eaten into by the water, and the less abundant can be the replenishment from the interior towards compensating for this consumption. Hence the ice must all melt away in time. Suppose now the sea, unobstructed by land from either pole to temperate or tropical regions, to be iceless at any time, would it continue iceless during the whole of the sunless polar winter? *Yes* we may safely answer. Supposing the depth of the sea to be not less than 50 or 100 fathoms, and judging from what we know for certain of ocean currents, we may safely say that differences of specific gravity of the water produced by difference of temperature not reaching anywhere down to the freezing point, would cause enough of circulation of water between the polar and temperate or tropical regions to supply all the heat radiated from the water within the arctic circle during the sunless winter, if air contributed none of it. Just think of a current of three quarters of a nautical mile per hour or 70 miles per four days, flowing towards the pole across

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the arctic circle. The area of the arctic circle* is 700 square miles for each mile of its circumference. Hence 40 fathoms deep of such a current would carry in, per twenty four hours, a little more than water enough to cover the whole area to a depth of 1 fathom: and this, if 7°·1 Cent. above the freezing point would bring in just enough of heat to prevent freezing, if in twenty four hours as much heat were radiated away as taken from a tenth of a fathom of ice-cold water would leave it ice at the freezing point. This is no doubt much more than the actual amount of radiation and the supposed current is probably much less than would be if the water were ice cold at the pole and 7° Cent. at the Arctic circle. Hence, without any assistance from air, we find in the convection of heat by water alone a sufficiently powerful influence to prevent any freezing up in polar regions at any time of year. But the air also must carry much heat—quantities of heat considerable in comparison with those carried by ocean currents, from temperate to polar regions. Think of a south wind of 15 nautical miles per hour through a space 2300 feet above the surface. The air thus in motion will be $\frac{1}{11}$ of the whole of the atmosphere over the region, and will therefore be equal in weight to 3 fathoms of water, and equal in thermal capacity to $\frac{3}{4}$ of a fathom of water. This, if at the same temperature as our previously supposed current of water of three quarters of a mile per hour will carry as much heat as 15 fathoms deep of the water current; without taking into account the latent heat of aqueous vapour condensed into liquid water in the air as it cools, which gives a large addition to the heat carrying capacity of wind in ordinary atmospheric conditions. For example air at 15° Cent. saturated with aqueous vapour must have twice as much heat taken from it as dry air at the same temperature, to cool it to 0° Cent.

According to my brother Prof. James Thomson's theory of the great primary and secondary circulations of the atmosphere, the earth's surface in the temperate and polar regions must always experience a prevalence of South west winds in the Northern hemisphere, and North west winds in the Southern hemisphere. The thermal estimates which we have just had under consideration show that these poleward winds must in all possible conditions as to distribution of land and water, have a great

* Being approximately plane, and of 1400 miles radius.

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direct influence in moderating the cold of the northern regions. They contribute also largely towards the same result by increasing the oceanic circulation, and would do so to a still greater degree if there were less of land than there is in the circumpolar and temperate regions.

Now what must be the climate of a small island in an open iceless circumpolar sea? Temperate, and quite free from frost except in hollows, we may I think safely answer. The water and air all round it are above the freezing point, and the air is saturated or nearly saturated with aqueous vapour. Wells' old theory of dew now helps us. When the sun is below the horizon the upper surface of the earth whether it be rock or stones or soil, or blades of grass or leaves of trees—whatever is unscreened from above, radiates as long as its temperature is higher than the average radiational temperature of the *atmosphere* and *space* above it. This temperature will be the temperature of the under side of the cloudy stratum, and will generally be above the freezing point if the atmosphere is thickly clouded: it will be perhaps not much above the temperature of planetary space* when the air is at its clearest. What then is there to prevent fine leaves of trees or grass in any part of the world from destruction by cooling down to near the temperature of space, in ten minutes after the sun sets? Answer: —*clouds;* or if not clouds, *wind;* or if neither clouds nor wind, *dew* and *ground mist;* clouds by moderating or annulling the radiation: wind by supplying heat from so considerable a mass of air that no part of it is cooled to the dew point: dew by the latent heat of the vapour from which it is formed when clouds and wind do not suffice to prevent the temperature from sinking to the dew point, and ground mist (or dew in the motionless stratum of air next the ground) by partially screening the ground from radiation and itself instead radiating heat which it draws from a thicker stratum of still air than could contribute sensibly by conduction to supply radiation from the ground. If these defences suffice to protect vegetation against destructive cold for a summer night over a flat continent in tropical or temperate regions it seems certain that they would suffice to prevent even so much as hoar frost on a small island at the very

* That is to say the temperature shown by a thermometer held in space on the night side of the earth a few thousand miles from it.

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pole during its whole winter six months night, if it is surrounded by a deep ocean with no land to obstruct free circulation between it and tropical seas.

Considering, then, the absolute proofs we have in Geology of subsidences and elevations of vast regions of the solid earth, I see no difficulty in admitting the complete sufficiency of the theory set forth in Lyell's twelfth chapter to account for all that is proved of temperate climates in polar regions, and of alternations of glacial and mild climates in Europe, and North America, and New Zealand. And if a few scratched stones prove (as there seems fair reason to believe they do) a glacial climate to have prevailed at one time in some part or parts of India, surely the 15000 feet elevation of a district required to account for it in that way is a smaller assumption than the 35000 feet diminution of distance from the earth's centre to the surface for thousands of miles round the locality needed to bring the pole to that region.

But the astronomical cause invoked by Herschel must have had, and must now have, its effect. It does not go for nothing that we are nearer the sun by one thirtieth of the mean distance in the midwinter than in the midsummer of the northern hemisphere, and in the midsummer than in the midwinter of the southern hemisphere. Eleven thousand five hundred years ago this was reversed,* and if the distribution of land and water were then the same or nearly the same in both hemispheres as at present, there must have been more difference between winter and summer in the northern hemisphere and less in the southern than now. And whatever effect on the seasons or climates of the two hemispheres is produced by the change in a few thousand years from being *nearest to the sun in winter* to *being nearest to the sun in summer*, much greater effect must have been produced when through the secular variation of the eccentricity of the earth's orbit the difference of distance has been three or four times as great as at present, as it has been probably more than once in the last million years. But what the precise character of this effect may be, or whether even at its greatest it can have been distinctly sensible among the undoubtedly potent influences depending on the distribution of land and sea, or whether it can have been

* Through the precession of the equinoxes and the secular variation of the position of the major axis of the earth's orbit.

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preponderant in giving rise to alternations of glacial and milder epochs as argued by Mr Croll in the interesting and suggestive speculations of his "Climate and Time", are very difficult questions which have not hitherto been validly dealt with, and which deserve the most careful consideration.

As to changes of the earth's axis, I need not repeat the statement of dynamical principles which I gave with experimental illustrations to the Society three years ago; but may remind you of the chief result which is that, for steady rotation, the axis round which the earth revolves must be a "principal axis of inertia", that is to say such an axis that the centrifugal forces called into play by the rotation balance one another. The vast transpositions of matter at the earth's surface, or else distortions of the whole solid mass, which must have taken place to alter the axis sufficiently to produce sensible change of the climate in any region must be considered and shown to be possible or probable before any hypothesis accounting for changes of climate by alterations of the axis can be admitted. This question has been exhaustively dealt with by Mr George Darwin in a paper recently communicated to the Royal Society of London, and the requisitions of dynamical mathematics for an alteration of even as much as two or three degrees in the earth's axis in what may be practically called geological time shown to be on purely geological grounds exceedingly improbable. But even suppose such a change as would bring ten or twenty degrees of more indulgent sky to the American Arctic Archipelago;—it would bring Nova Zembla and Siberia by so much nearer to the pole: and it seems that there is probably as much need of accounting for a warm climate on one side as on the other of the pole. There is in fact no evidence in geological climate throughout those parts of the world which geological investigation has reached, to give any indication of the poles having been anywhere but where they are, at any period of geological time.

Pass now from the evidence of a temperate climate, allowing vegetation such as at present lives in the North of Europe, to have lived all over the Arctic islands at a not very remote geological epoch, of which we have found a perfectly satisfactory explanation in Lyell's hypothesis of the submergence of the circumpolar land barriers; and consider next the evidence with which geological investigation teems of warmer climate all over

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the earth from equator to poles in the more ancient geological periods. Underground heat, though certainly greater in the earlier geological times, cannot, as I have shown elsewhere,* have ever sensibly influenced the climate. Ten, twenty, thirty times the present rate of augmentation of temperature downwards could not raise the surface temperature of the earth and air in contact with it by more than a small fraction of a degree Fahrenheit. The earth might be a globe of white hot iron covered with a crust of rock 2000 feet, or there might be an ice-cold temperature everywhere within 30 feet of the surface, yet the climate could not on that account be sensibly different from what it is, or the soil be sensibly more or less genial than it is for the roots of trees or smaller plants. Yet greater underground heat is the hypothesis which has been most complacently dealt with by geologists to account for the warmer climates of ancient times. The one hypothesis of all hitherto suggested that has received no favour from any professed geologist is that of a warmer sun—the one hypothesis that is rendered almost infinitely probable by independent physical evidence and mathematical calculation.

XVIII.—Notes *on the* Fossils of the Orchard Limestone Series. By James Armstrong and John Young, F.G.S.

[Read 13th May, 1875].

In this paper we purpose giving a list of all the named fossils from the shales and limestone of the Orchard series, so far as known to us. The Orchard limestone, so called from having long been worked as a valuable cement on the farm of Orchard, near Pollokshaws, Renfrewshire, lies at the base of the upper limestone series in the coal basin of the Clyde. In the district south of the Clyde it is known in different localities under different names, viz., as the Lyoncross limestone at Nitshill and Barrhead, and as the Williamwood limestone at Cathcart. Orchard, however, is the place where it has been longest worked, and where it has been most thoroughly explored for its fossil remains, and where specimens may still be obtained at the workings, or by searching the old shale heaps. As already

* "Secular Cooling of the Earth," Trans. R.S.E., 1862, and Thomson and Tait's Natural Philosophy, Vol. I., App. D.

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stated, it is a cement limestone of the calmy variety, and in the above districts varies from 18 to 30 inches in thickness, being sometimes separated into two bands by a thin parting of shale. It is of a bluish-grey colour when newly quarried, but on exposure to the atmosphere it weathers into a yellowish-grey, from the presence of a little iron in the stone. It is worked both by open cast quarries and by mining, and is burnt in open kilns, and afterwards ground to a powder before being sent to the market. It sets with a strong band under water, and brings a good price as a hydraulic cement, although its rather dark reddish-brown colour prevents it from being as largely employed for external work as the lighter coloured Portland cement from England.

Taking the Index or Cowglen limestone of the Pollokshaws district as the lowest limestone of the upper limestone series of the Clyde coal basin, we have, in ascending series over it, first, the thick-bedded sandstones of the Giffnock and Bishopbriggs quarries; second, a little higher in the series, the Orchard cement limestone and shales; and third, the Arden and Robroyston limestone on a still higher horizon; the latter being made the boundary stratum between the higher beds of the carboniferous limestone and the millstone grit group. This upper group of limestones, with their accompanying strata, forms a well marked division between the overlying millstone grit on the one hand, and the underlying coals and ironstones on the other, these latter in their turn resting on the lower group of carboniferous limestone strata. The stratum of impure cement limestone found overlying the sandstone of the Bishopbriggs quarries north of the Clyde is believed to be the equivalent of the Orchard limestone; but with the accompanying shale, is much more ferruginous and arenaceous. It is held in little esteem as a cement, only a small quantity having been brought to market; but, nevertheless, is laid aside in heaps at the quarries, with the expectation that should richer cements become scarce in the district, it might rise in value. These cement heaps at Bishopbriggs quarries, from their bright orange-brown colour when weathered, afford a strong contrast to the sandstone heaps which are of a white and whitish-grey colour.

The differences of this cement stratum in the districts north and south of the Clyde may have been produced by varying conditions of the sea bottom at the period of deposition; that at Bishopbriggs having probably been laid down in shallower water.

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These varying conditions have also effected to a certain extent the character and distribution of the marine life present, the upper thin band of cement-stone at Bishopbriggs being characterized by the occurrence of *Myacites* and *Pinna* in the erect position in which they lived in the deposit, while these shells are absent in the lower stratum of cement at this place, as well as in the limestone at Orchard. The list of species given at the end of our paper shows the species that are found in these beds north and south of the Clyde, as well as those that have only been found in one or other of the localities.

The Orchard limestone, like many of the cement or calmy limestones of Western Scotland, is not rich in fossils, and we are not aware that it contains any species which has not been found in the more rich overlying fossiliferous shale. It is therefore more a chemically than an organically formed limestone, its few fossils only occurring throughout the bed at intervals, in a crushed and often poorly preserved condition. The shale, above the limestone, in which the fossils are found is of a dark bluish-grey colour. It forms only a comparatively thin bed, and passes upwards into a dark clay shale of a slaty structure, in which few fossils are to be obtained. It breaks up readily into a soft clay under the influence of the weather, and while in this state it can either be readily washed for the more minute organisms, or searched upon the old shale heaps for the larger forms, the shale heaps having yielded from time to time many interesting specimens. As the locality is within easy reach of members of this Society, it has consequently been often visited; we are therefore able to give a more complete list of the organisms it contains, than of localities that lie at a greater distance from the city. It may here be remarked that the Orchard shale is rich neither in species of crinoids, corals, nor polyzoa, its characteristic fossils being shells of the univalve and bivalve groups, along with Entomostraca and Foraminifera, these latter groups of organisms never being so abundant in strata in which crinoids, corals, or polyzoa abound. Such being the case, it points to the conclusion that depth of water, temperature, and nature of the sediments laid down over the various areas of the carboniferous old sea bottom, may each have had their influence in regulating the kind of life that flourished over the several tracts.

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CATALOGUE OF THE ORCHARD FOSSILS.

PLANTÆ.

Pieces of flattened carbonized stems are not uncommon in the shale.

PROTOZOA.

FORAMINIFERA.

1. ENDOTHYRA AMMONOIDES, *Brady*.
   This and the following species of Foraminifera, except No. 3, are obtained from the shale washings.

2. E. RADIATA, *Brady*.
   Rare.

3. STACHEIA POLYTREMOIDES, *Brady*.
   Common on crinoid stems at Williamwood.

4. TROCHAMMINA INCERTA, *D'Orbigny*.
   Rare.

5. VALVULINA PALÆOTROCHUS, *Ehrenberg*.
   Rare.

ACTINOZOA.

1. LITHODENDRON JUNCEUM, *Fleming*.
   Rare. In the shale.

2. STENOPORA TUMIDA, *Phillips*.
   Rare. In the shale.

3. ZAPHRENTIS PHILLIPSI, *Milne Edwards*.
   Common. In the shale.

4. ZAPHRENTIS, *sp*.
   Rare. In the shale.

ECHINODERMATA.

1. ARCHÆOCIDARIS UREI, *Flem*.
   Fragments of spines and plates found in the shale, but very rare.

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2. PISOCRINUS GLOBULARIS, *De Koninck.*
Rare. Plates of the calyx in the shale.

3. PLATYCRINUS TRIGINTIDACTYLUS, *Austin.*
Rare. Pieces of the arms in the shale.

4. POTERIOCRINUS CRASSUS, *Miller.*
Portions of stems are common, but remains of the calyx are of very rare occurrence.

ANNELIDA.

1. SERPULITES MEMBRANACEUS, *M'Coy.*
Very rare. In the shale.

2. ORTONIA CARBONARIA, *J. Young.*
Very rare. In the Shale.

CRUSTACEA.

1. BAIRDIA CURTA, *var.* PLEBEIA, *Jones* and *Kirkby.*
Common. Found in the shale washings along with the following species, except Nos. 11 and 12.

2. B. SUBCYLINDRICA, *Münster.*
Common.

3. B. SUBMUCRONATA, *J.* and *K.*
Rare.

4. BEYRICHIA BITUBERCULATA, *M'Coy.*
Common.

5. B. COLLICULUS, ? *D'Eichwald.*
Rare.

B. RADIATA, *J.* and *K.*
Common.

7. B. RIGIDA, *J.* and *K.*
Moderately common.

8. CYTHERE CORNIGERA, *J.* and *K.*
Common.

9. C. CUNEOLA, *J.* and *K.*
Common.

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10. C. VENTRICORNIS, *J.* and *K.*
Common.

11. DITHYROCARIS TESTUDINEUS, *Scouler.*
Teeth are not uncommon in small nodules in the shale, but no portions of the carapace have been found.

12. GRIFFITHIDES EICHWALDI, *Fischer.*
Very rare. In the shale.

13. KIRKBYA ANNECTENS, *J.* and *K.*
Rare.

14. K. BIPARTITA, *J.* and *K.*
Rare.

15. K. PERMIANA, *Jones.*
Moderately common.

16. LEPERDITIA OKENI, *Münst.*
Common.

POLYZOA.

1. CARINELLA CELLULIFERA, *Etheridge.*
Very rare. In the shale.

2. FENESTELLA, *sp.*
Small fragments of probably more than one species found in the shale, but they are of rare occurrence.

BRACHIOPODA.

1. ATHYRIS AMBIGUA, *Sowerby.*
Common and of larger dimensions than in most Scottish localities, but perfect examples are rather rare. The detached valves are frequently found shewing the muscular impressions in fine preservation.

2. CHONETES LAGUESSIANA, *De Kon.*
Rare, and of small size.

3. CRANIA QUADRATA, *M'Coy.*
Rare. Chiefly on shells.

4. DISCINA NITIDA, *Phill.*
Common, and in fine preservation.

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5. LINGULA MYTILOIDES, *Sow.*

Common. Chiefly in small nodules, and in beautiful preservation. Found similarly at Bishopbriggs in the shale above the limestone.

6. L. SQUAMIFORMIS, *Phill.*

Very rare. Found along with the preceding species at Bishopbriggs, where it is common.

7. ORTHIS MICHELINI, *Léveillé.*

Very rare. In the shale, and in pieces.

8. O. RESUPINATA, *Martin.*

Very rare. In the shale, of small size, in fair preservation.

9. PRODUCTUS CORA, *D'Orb.*

Very rare. An imperfect ventral valve.

10. P. COSTATUS, *J. de C. Sow.*

Common. In the shale, of full size, and in excellent preservation. Usually the ventral valve only is found; the dorsal, with the muscular impressions, is rare. This would seem to be the metropolis of this species in the West of Scotland.

11. P. GIGANTEUS, *Mart.*

Very rare. Both in the limestone and shale; of small dimensions.

12. P. LONGISPINUS, *Sow.*

Rare. In the shale.

13. P. SCABRICULUS, *Mart.*

A single example. In the shale.

14. P. SEMIRETICULATUS, *Mart.*

Rare. In the shale. Found in the limestone at Bishopbriggs.

15. P. YOUNGIANUS, *Davidson.*

Rare. In the shale.

16. SPIRIFERA GLABRA, *Mart.*

Very rare. In the shale.

17. S. OVALIS.

Very rare. In the limestone; one imperfect example.

18. S. LINEATA, *Mart.*

Very rare. In the shale; of small size, but good preservation.

19. S. TRIGONALIS, *var.* BISULCATA, *Sow.*

Very rare. In the shale, in fragments.

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20. S. Urei, *Flem.*
Very rare. In the shale.

21. Spiriferina insculpta, *Phill.*
Very rare. In the shale.

22. Streptorhynchus crenistria, *Phill.*
Common. In the shale. Many examples are large and but little crushed, and the external sculpture is sharp and distinct, while the characters of the hinge area and the muscular impressions are well displayed in many of the separated valves. The variety *radialis* occurs but it is very rare.

23. Strophomena rhomboidalis, *var.* analoga, *Phill.*
Very rare. In the shale.

LAMELLIBRANCHIATA.

MONOMYARIA.

1. Aviculopecten celatus, *M'Coy.*
Very rare. In the shale.

2. A. simplex, *De Kon.*
Very rare. A single example in the shale.

DIMYARIA.

3. Pinna spatula, *M'Coy.*
A single fragment in the shale.

4. Posidonomya corrugata, *Ether.*
Very rare.

5. Arca Lacordairiana, *De Kon.*
Very rare. In the limestone and shale. In the latter the specimens are in a beautiful state of preservation.

6. Axinus carbonarius, *Portlock.*
Very rare. In the shale.

7. A. deltoideus, *Phill.*
Very rare. In the limestone.

8. Cardiomorpha, *sp.*
A single example in the shale.

9. Conocardium decussatum, *Ether.* Geol. Mag., Decade 1, Vol. X., p. 112.
Very rare. Williamwood shale. One example only.

10. Cypricardia acuticarinata, *Armstrong.*
Rare. Perfect examples in the shale and limestone. The best locality in the West of Scotland for this beautiful shell.

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11. C. RHOMBEA, *Phill.*
Common. In the limestone and shale; well preserved.

12. LEDA ATTENUATA, *Flem.*
Common. In the shale; large and well preserved. Occurs also in the shale above the limestone at Bishopbriggs.

13. L. CLAVATA, *M'Coy.*
Common. In the shale, well preserved, and in the limestone.

14. L. INTERMEDIA, *Ether.*
Rare. In the shale, and well preserved.

15. L. OBLONGA, ? *M'Coy.*
Rare. In the shale; well preserved.

16. MYACITES SULCATA, *Flem.*
Very rare. In the shale.

17. NUCULA ACUTA, *Sow.*
Very rare. Three or four examples in the shale in perfect condition.

18. N. GIBBOSA, *Flem.*
Common. In the limestone and shale, Bishopbriggs.

19. N. LINEATA, *Phill.*
Common. In the shale.

20. N. LUCINIFORMIS, *Phill.*
Rare. In the shale, Bishopbriggs.

21. N. YOUNGI, *Ether.* Ann. and Mag. Nat. Hist., Series 4, Vol. XVIII., p. 104, pl. iv., figs. 11–13.
Common. In the shale.

22. SOLENOPSIS MINOR, *M'Coy.*
Very rare. A single example in the shale.

23. VENUS ELLIPTICA, ? *Phill.*
Very rare. A single valve.

24. VENUS, ? *sp.*
A small species, rarely exceeding ¼ of an inch in size, is common, and easily obtained in the shale workings.

GASTEROPODA.

1. CHITON BURROWIANUS, ? *Kirkby.*
Very rare. A posterior plate in the Williamwood shale.

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2. DENTALIUM INORNATUM, *M'Coy.*
Very rare. In the shale.

3. D. PRISCUM, *Goldfuss.*
Very rare. In the shale.

4. EULIMA PHILLIPSIANA, *De Kon.*
Common. In the shale.

5. EUOMPHALUS CARBONARIUS, *Sow.*
In the shale, and very abundant.

6. E. PILEOPSIDEUS, *Phill.*
A single example in the Williamwood shale.

7. LOXONEMA CONSTRICTA, ? *Mart.*
Very rare. A single example in the shale, which closely approaches this species.

8. L. CLATHRATULA, *Young* and *Armst.*
Very rare. In the shale.

9. L. LEFEBVREI, ? *Lév.*
Very rare. In the shale.

10. L. SCALAROIDEA, *Phill.*
Common. In the shale.

11. MACROCHEILUS ACUTUS, *Sow.*
Common. In the shale; small examples.

12. M. IMBRICATUS, *Sow.*
Rare. In the shale; Bishopbriggs in the shale above the limestone.

13. M. SEMISTRIATUS, *Y.* and *A.*
Very rare. In the shale.

14. MURCHISONIA STRIATULA, *De Kon.*
Common. In the shale.

15. NATICOPSIS ROBROYSTONENSIS, *Y.* and *A.*
Not uncommon. Small specimens in the shale.

16. N. VARIATA, *Phill.*
Very rare. One or two specimens in the shale.

17. PLATYCERAS NERITOIDES, *Phill.*
Very rare. A single example in the shale.

18. PLEUROTOMARIA FRENOYANA, *De Kon.*
Very rare. A few examples in the shale.

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19. P. MONILIFERA, *Phill.*
Common. In the shale and limestone; well preserved.

20. P. YVANII, *Lév.*
Not common, and of small size both in the limestone and shale.

HETEROPODA.

1. BELLEROPHON DECUSSATUS, *Flem.*
Rare. In the limestone and shale.

2. B. LEVEILLEANUS, ? *De Kon.*
In the shale; not abundant, but in very fair preservation. Prof. de Koninck, who has examined our specimens, is of opinion that this is a species distinct from the Belgian form.

3. B. UREI, *Flem.*
Common. In the shale; tolerably large.

4. PORCELLIA ARMATA, *De Verneuil.*
One example in the shale.

PTEROPODA.

1. CONULARIA IRREGULARIS, *De Kon.*
Very rare. A fragment in the shale.

2. C. QUADRISULCATA, *Sow.*
Rare. In the Shale.

CEPHALOPODA.

1. ACTINOCERAS GIGANTEUM, *Sow.*
Rare; but usually in good preservation, and useful for polished sections. Some of the examples have the shell eroded on one side, so as to show the siphuncle and chambers. A specimen in the Hunterian Museum measures 3 feet in length.

2. CYRTOCERAS RUGOSUM, *Flem.*
Very rare. A few fragments in the shale.

3. C. UNGUIS, *Phill.*
Very rare. In the shale.

4. GONIATITES STRIOLATUS, *Phill.*
Very rare. In the shale.

5. G. VESICA, *Phill.*
Very rare. One or two in the shale in indifferent preservation.

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6. NAUTILUS GLOBATUS, *Sow.*
Very rare. A single example in the shale.

7. N. NODIFERUS, *Armst.*
A few fragments have been found in the shale.

8. N. QUADRATUS, *Flem.*
Very rare. In small pieces in the shale.

9. ORTHOCERAS ATTENUATUM, *Flem.*
Common. In the shale, in fragments.

10. O. OVALE, *Phill.*
Not uncommon. In the shale.

11. O. SUBCENTRALE, *De Kon.*
Rare. In the shale; in well preserved pieces, sometimes upwards of a foot in length, and showing the surface ornamentation.

12. O. UNDATUM, *Flem.*
Rare. In the shale; in short fragments, but with the shell well preserved.

PISCES.

1. TOMODUS CONVEXUS, *Agassiz.*
Very rare.

2. RHIZODOPSIS GRANULATUS, *Ag.*
Common. In ironstone nodules in the shale.

ABSTRACT.

No.	Classes.	Genera.	Species.
1	Protozoa,	4	5
2	Actinozoa,	3	4
3	Echinodermata,	4	4
4	Annelida,	2	2
5	Crustacea,	7	16
6	Polyzoa,	2	2
7	Brachiopoda,	11	23
8	Lamellibranchiata,	13	24
9	Gasteropoda,	10	20
10	Heteropoda,	2	4
11	Pteropoda,	1	2
12	Cephalopoda,	5	12
13	Pisces,	2	2
	Total,	66	120

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XIX.—*Remarks on the* WEALDEN BORINGS. By D. C. GLEN, F.G.S.

[Read 9th Dec., 1875.]

I MAY preface my remarks on the Wealden boring by giving a short description of the various modes of conducting, and of the machinery used in, what miners call "boring." The object of making a bore is to ascertain the presence of certain strata and at what depth they lie, or it may be made for the purpose of getting a supply of water, of oil, or of gas. When the ground through which the bore passes is soft, the method of working is with, what carpenters would call, a shell auger, worked with a cross handle fixed at the upper end, by manual labour. As the hole gets deep additional lengths of rod are screwed on to the first one, until the required depth is reached. Of course, during this process the rods and auger have to be withdrawn from time to time to clear out the chamber at the lower end, which becomes filled with the *debris* from the bore, and from the inspection of this *debris* a knowledge of the various formations through which the bore has passed is obtained.

When hard substances have to be passed through, a steel chisel-pointed "jumper" is used, being alternately raised and dropped by the workmen. In this case the *debris* has to be removed from the bore by a tube fitted with a valve at the lower end, and as the jumper has to be worked in water, it is in the form of mud. Portions of the upper strata already bored sometimes fall into the hole, and therefore the muddy contents of the tube may not always be a correct indication of the substance last passed through. To obviate this the upper parts of the bore are often lined with tubing, which prevents sand, or water, or portions of the strata, from passing downwards. When the hole gets deep, and the rods consequently too heavy for hand work, a long lever is attached to the top end, or sometimes a steam engine is used, to give the proper percussion, or jumping action, to the boring rods. To save the time lost in continually withdrawing the rods from the hole, the Chinese have a plan of using a rope instead of stiff rods. But this is objectionable, as sometimes the hole is bored untrue, and if the rope breaks the heavy chisel is left in the bore. In this country Messrs Mather & Platt, of Manchester, have made some remarkable borings by their ingenious cutter,

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worked by a flat wire rope. An improved method of boring, compared with that by the chisel-jumper, is to have a tube with steel cutters forming a saw, which, being made to revolve, cuts out a solid core or cylinder of the rock. When brought to the surface this cylinder, therefore, not only gives a true sample of the material through which the bore passes, but also shows the dip or inclination of the strata. This system has again been improved upon by Major Beaumont, R.E., by having a steel tube, faced in the lower end with a number of rough uncrystallized diamonds, which are known as "carbonite." Unlike the others, this boring tool is made to revolve with its face in constant contact with the rock, very like the mode of working a drill or cutter used in boring iron. A jet of water is forced down the centre of the hollow boring rods, so that the face of the cutters may be kept cool, while at the same time the *debris* is carried up by the overflow to the surface. This drill can be worked at a speed of 250 revolutions per minute, with a pressure of from 400 to 800 lbs. per square inch. It will then bore granite and the hardest limestones, at the rate of 2 to 3 inches, sandstone at 4 inches, and quartz at 1 inch, per minute, and this is the system which has been successfully applied to the Wealden boring.

The above-mentioned carbonite or uncrystallized diamond, has of late been much used for the cutting or dressing of French burr millstones. This is done by fixing a diamond in a small steel holder, and working it in a straight slide fixed over the face of the stone, which the diamond cuts or scratches into a suitable grinding surface. Latterly carbonite has been applied to the dressing of sandstone ashlar. A number of diamonds are fixed into a block of gun-metal or steel, which is then worked with a reciprocating and traversing motion over the face of the stone to be operated on. It is expected, that when this machine is finally completed, it will dress from 600 to 1000 square feet per day, or as much as 100 to 150 men could do in the same time.

The following are examples of deep bores and shafts. The Artesian well at Grenelle, near Paris, is 1798 feet in depth, the bore passing into the Gault. It yields 516 gallons of water per minute, which rises to a height of 32 feet above the surface, its temperature being 81½ Fahr. The well in Trafalgar Square, London, is 393 feet deep, and goes down to the Upper Chalk. A borehole made to explore the coal-measures at Creuzot in France,

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by Herr Kind, is 920 metres, or 3029 English feet. The bore at Sperenberg, in Prussia, 23 miles south of Berlin, is said to be the deepest in the world, having reached 4172 English feet, and cost £8717, or about 43s per foot. The deepest coal-pit in Scotland is the Victoria Pit at Nitshill, where the Hurlet coal is worked. It is 175 fathoms, or 1050 feet in depth. The Monkwearmouth Pit, near Sunderland, was for many years the deepest in England—it is 300 fathoms, or 1800 feet. Another pit in the same neighbourhood, but lying more towards the dip of the coalfield, is a few fathoms deeper. The deepest pit in England now is at Dukenfield, near Manchester, and belongs to Mr Astley. Its depth is 408 fathoms, or 2446 feet, and it passes through 22 workable seams of coal. The deepest pits in the world are now in Belgium—in the coalfield running from Mons to Charleroi. The shafts in several cases are over 750 metres, or 2460 feet; and one shaft, at Gilly, near Charleroi, is 1040 metres, or 3411 feet in depth; while one part has reached the depth of 3489 feet.

The Wealden formation, which is of fresh water origin, takes its name from the Weald, an ancient Saxon district comprising parts of Kent, Surrey, and Sussex. It was first described by Dr Mantell in 1822, and lies below the Chalk and above the Oolite. It appears also in the Isle of Wight, but is of limited extent in England. On the Continent it is found in France and Belgium. It seems to occupy the site of an ancient estuary which received the clay and mud of some gigantic river, and whose waters carried down the remains of land plants and animals now entombed with those of aquatic origin. The Wealden consists of thick beds of sandstones, shales, limestones, and blue clays, having in various places septaria of argillaceous ironstone, and in the upper, beds of shelly fresh-water limestone, (*Paludina* limestone) known in Sussex as Petworth marble. The general appearance of the Wealden rocks not unfrequently resembles that of some of the coal-measures of the true Carboniferous period. Dr Page, in his excellent work, entitled "Economic Geology," gives the useful products of the Wealden formation, as follows:—

Sands for mortar, metal moulding, and glass making.
Clays for tile and brick making.
Sandstones, of fair quality, for building and paving.
Ironstones (clay carbonate) in bands and nodules; at one time worked as iron ore.

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Shelly marbles *(Paludina)*, Sussex, and Petworth marbles; at one time much, and still occasionally, used for ornamental purposes.

Gypsum of compact, white, and pure quality, discovered in the Sub-Wealden borings of 1873 and 1874.

The origin of the Wealden boring is, I think, in a great measure due to Mr Godwin-Austin, who suggested, in the Quarterly Journal of the Geological Society (vol. xii., p. 73), that the coal measures might possibly be found under London, and the south-eastern part of England; his reasoning being that as coal is worked under the Chalk at Valenciennes in France, and has been found in recent sinkings towards Calais, it might extend across the Channel and occur under similar cretaceous rocks in the south of England. Sir Roderick Murchison, however, held a different opinion, that the strata underneath the Wealden formation would probably prove to be a thin band of Carboniferous limestone without any productive coal, or more probably might be Devonian rocks only. Since that time a bore was put down near Harwich to a depth of 1070 feet, but was abandoned when it reached a hard slatey palæozoic rock immediately underlying the Gault, and which showed distinct cleavage. The lower members of the cretaceous series, together with the whole of the Jurassic and Triassic rocks, were entirely absent. The idea of a new boring was brought up by Mr Willett, just before the British Association meeting held at Brighton in 1872. Subscriptions towards the expense were then received, and shortly afterwards operations were begun. For the following facts relating to the history of the work itself I am indebted to the quarterly reports of the Sub-Wealden Exploration Committee, the members of which comprise some of our most eminent scientific men. The report issued in June, 1874, gives the following statistics:—

Bored since 28th March, 1874, ...	329 feet.
Greatest weekly progress, ...	86 ,,
Total depth attained, ...	1018 ,,

The facts represented by these figures are not readily realized. Every time the boring tool is lowered, more than 50 joints have to be accurately screwed together; the time occupied in this operation exceeding 90 minutes. In fact, at this depth, the boring itself does not take much more than half the time occupied, most watchful care and attention being needed in securing the joints. On

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Saturday, June 6, owing to the fracture of a pin in the clutch, about 500 feet of boring rod, with the auger attached, fell to the bottom. It was caught on the following Monday, and drawn 560 feet; where, meeting with an obstruction from the falling-in of a side, it resisted all efforts to extract it further. This was an emergency which brought out in strong relief the superiority of the diamond boring system over all others; for profiting by past misfortune of this kind, the upper part of the auger (which has a diameter of nearly two inches more than the rods) had been, with admirable foresight, armed with boring diamonds in order, as in this case, to *bore upwards* through any obstruction. Had it not been for this forethought the accident would, in all probability, have put an end to the work. As it was, it took nearly a fortnight of steady *upward* boring before the tool could be freed. Notwithstanding this delay, on coming to the surface, the auger was found uninjured, and contained about *eight feet of core*. This was the only mishap, and on the 18th of June, 1874, the 1000 feet were completed. A new boring was commenced on February 11th, 1875, and on August 23d, Mr Willett, the energetic secretary, wrote:—"With our iron boring rod we have succeeded in exploring *one-third of a mile* (1760 feet) towards the earth's centre. We have, therefore, succeeded beyond our fondest expectations in solving the original problem, and can now state with certainty that 'palæozoic rocks do not exist' at a depth variously estimated at from 700 to 1700 feet. From 1670 to 1750 feet the strata are shattered and very soft, greatly retarding the operation, and seriously imperilling our prospects of attaining a much greater depth. You must be prepared, therefore, for the announcement that the work is brought to a close. The last cores, though not exceeding one inch in diameter, have abundant traces of extinct life, *Lingula*, *Thracia*, *Cardium*, and *Ammonites*."

Since this paper was written, the second borehole has been prosecuted, in spite of many difficulties, to the depth of 1903 feet. The details of the strata are given in the accompanying section. The various formations passed through have been arranged as follows by Mr W. Topley, F.G.S. The first 200 feet are Purbeck beds, then 57 feet of Portland beds, 1512 feet Kimmeridge clay, 17 feet Coralline Oolite, and 117 feet, possibly of Oxford clay. The object of the boring has not therefore been accomplished, which was to reach the Palæozoic rocks.

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The discovery of thick beds of valuable Gypsum (which are now being worked for commercial purposes), has perhaps been the most profitable result gained from this, the first bore for purely scientific purposes which has ever been put down in England.

SECTION OF STRATA AT SUB-WEALDEN EXPLORATION BORING AT NETHERFIELD, NEAR BATTLE, SUSSEX.

Description of Strata.	Thickness of Strata.		Depth from Surface.	
	Ft.	In.	Ft.	In.
Surface,	16	0	16	0
Soft Shale,	1	0	17	0
Blue Limestone,	1	6	18	6
Calcareous Shale,	6	0	24	6
Blue Limestone,	1	0	25	6
Calcareous Shale,	1	0	26	6
Soft Shale,	3	0	29	6
Limestone,	1	6	31	0
Calcareous Shale,	0	6	31	6
Strong Shale,	3	0	34	6
Calcareous Shale,	1	0	35	6
Blue Limestone,	2	6	38	0
Calcareous Shale,	1	0	39	0
Strong Shale,	6	0	45	0
Blue Limestone,	2	0	47	0
Shale,	0	6	47	6
Hard Limestone,	1	6	49	0
Limestone Soft Shale,	8	0	57	0
Shale,	5	0	62	0
Calcareous Shale,	1	0	63	0
Shale,	7	0	70	0
Blue Limestone,	1	0	71	0
Strong Shale,	6	3	77	3
Compact Blue Limestone,	1	3	78	6
Strong Shale,	6	9	85	3
Calcareous Shale,	2	6	87	9
Strong Shale,	6	2	93	11
Limestone,	0	1	94	0
Strong Shale,	5	0	99	0
Compact Hard Shale,	7	0	106	0
Calcareous Shale,	2	4	108	4
Hard Limestone,	0	8	109	0
Hard Blue Shale,	6	6	115	6
Blue Limestone,	1	0	116	6
Dark Blue Shale,	6	6	123	0
Shaley Limestone with thin veins of broken Gypsum,	4	0	127	0

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Description of Strata.	Thickness of Strata.		Depth from Surface.	
	Ft.	In.	Ft.	In.
Impure Gypsum,	6	0	133	0
Limestone and Gypsum,	1	0	134	0
Shaley Gypsum,	2	3	136	3
Gypsum in Crystals—veins in Shale,	7	6	143	9
Gypsum in veins and nodules,	3	6	147	3
Gypsum with veins of Limestone,	1	0	148	3
Strong Shale with veins of Gypsum,	0	6	148	9
Strong Shale and nodules of Gypsum,	4	3	153	0
Gypsum more or less pure,	7	9	160	9
Strong Shale with Gypsum,	3	3	164	0
Gypsum nearly pure with veins of Carbonate of Lime,	4	4	168	4
Cavity,	4	0	172	4
Limestone and Flint,	4	4	176	8
Soft Shaley Sandstone and nodules of Limestone and Flint,	16	0	192	8
Soft sandy Shale,	7	4	200	0
Soft whitish Sandstone,	52	0	252	0
Soft Sandstone darker in colour,	5	0	257	0
Sandy Shale,	17	0	274	0
Kimmeridge Clay,	154	0	428	0
Kimmeridge Clay more solid and compact,	44	0	472	0
Kimmeridge Clay much softer,	23	0	495	0
Kimmeridge Clay more solid and compact,	26	0	521	0
Kimmeridge Clay with traces of Carbonate of Lime,	20	0	541	0
Kimmeridge Clay dark brown with veins of Jet at 550′ 0″	66	0	607	0
Brown Limestone,	1	6	608	6
Kimmeridge Clay,	3	0	611	6
Brown Limestone,	0	6	612	0
Kimmeridge Clay,	27	0	639	0
Kimmeridge Clay with veins of Carbonate of Lime,	40	0	679	0
Kimmeridge Clay very Limey,	21	0	700	0
Kimmeridge Clay and veins of Carbonate of Lime darker and full of fossils,	24	0	724	0
Kimmeridge Clay and veins of Carbonate of Lime,	57	0	781	0
Kimmeridge Clay,	19	0	800	0
Kimmeridge Clay with veins of Carbonate of Lime,	10	0	810	0
Kimmeridge Clay,	72	0	882	0
Kimmeridge Clay and hard bands of Limestone, very soft place at 922′ 0″,	57	0	939	0

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Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
Kimmeridge Clay,	16	0	955	0
Oxford Clay with veins of Carbonate of Lime,	28	0	983	0
Oxford Clay, hard and rather more Limey,	9	0	992	0
Sandstone very soft and veins of Carbonate of Lime,	12	0	1004	0
Sandstone rather Shaley and very full of fossils,	41	0	1045	0
Sandy Shale very full of slips,	2	0	1047	0
Sandy Shale more solid and compact,	17	0	1064	0
Sandy Shale and nodules of Limestone,	28	0	1092	0
Shaley Sandstone,	37	0	1129	0
Sandstone very Shaley,	8	0	1137	0
Shaley Limestone,	27	0	1164	0
Light blue Limestone,	4	0	1168	0
Shaley Limestone,	14	0	1182	0
Calcareous Shale,	28	0	1210	0
Calcareous Shale more free from Sand,	26	0	1236	0
Very Clayey Shale like Oxford Clay,	19	0	1255	0
Calcareous Shale,	21	6	1276	6
Soft dark gritty Limestone,	28	6	1305	0
Calcareous Shale,	20	0	1325	0
Friable Calcareous Grit,	17	0	1342	0
Soft Calcareous Grit with bands of hard Limestone,	24	0	1366	0
Calcareous Sandstone,	4	0	1370	0
Blue Limestone changing into Shale,	27	0	1397	0
Strong blue Shale with few fossils,	19	0	1416	0
Strong blue Shale,	4	0	1420	0
Calcareous Sandstone,	10	0	1430	0
Calcareous Shale,	36	0	1466	0
Blue Shale, very few fossils,	11	0	1477	0
Blue Shale with traces of Encrinites and other fossils,	87	0	1564	0
Calcareous Shale with hard bands of Limestone,	88	0	1652	0
Light blue Limestone,	10	0	1662	0
Calcareous Shale and fossils,	9	0	1671	0
Calcareous Shale with hard Limestone,	27	0	1698	0
Very soft dark Shale containing a great many fossils,	59	0	1757	0
Strong dark Shale,	12	0	1769	0
Hard grey Limestone,	16	0	1785	0
Do.	1	0	1786	0
Dark Sandy Shale,	26	0	1812	0
Dark Shale,	12	6	1824	6

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Description of Strata.	Thickness of Strata.		Depth from Surface.	
	Ft.	In.	Ft.	In.
Soft Shale,	36	6	1861	0
Shale,	10	0	1871	0
Limestone,	16	0	1887	0
Hard dark Shale,	7	0	1894	0
Dark Shale,	9	0	1903	0

XX.—Remarks *upon the* Bed of Dolerite *which crosses* Renfrewshire *to the* east of Paisley. By Robert Craig, corresponding member.

[Read 13th January, 1876.]

In carrying out certain geological investigations in Renfrewshire some years ago, I became acquainted with a dolerite bed, crossing the county nearly from south to north, on the east of Paisley, and which is worked as a surface section at Seedhills. Its thickness there is about 22 feet, varying, so far as has been ascertained, from 22 feet to 25 feet. Where not exposed to atmospheric action it is a hard, pure dolerite, splitting with a straight, smooth surface, which makes it very suitable for paving-stones. It is a bed, and not a dyke; the dip being generally to the south-east, and corresponding with that of the adjacent strata; at Seedhills it is 8 degrees.* Its strike, as already mentioned, is usually nearly north and south, with a slight bearing to the east; but still is very irregular, running with ragged edges, sometimes jutting out, as at Seedhills, from 100 to 200 yards to the west, and at other times withdrawing within the main line to the east, as it appears to do north of Arkleston farm-house. At present I have not discovered its true horizon in the Carboniferous strata, but I will put it down, provisionally, above the main limestone and below the clayband ironstone of the Possil series. At one time I was inclined to place it below the main limestone, as I thought that the Blackhall limestone, which lies about 60 feet above it, was an upthrow of the main bed, but further search does not bear out that opinion.

A bore put down at Saucel, a little to the west of the outcrop

* Not 38° as stated in a paper on the glacial deposits of Renfrewshire, and which was published in the Society's Transactions, Vol. iv., page 140.

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of this bed at Seedhills, has shown the following strata underlying the dolerite. Hard amorphous sandstone, upon which the dolerite rests, about 40 feet thick: no correct journal of this part of the bore was kept, and it is probable that the sandstone is broken by beds of shale. Below the sandstone, 24 fathoms of fire-clay with ironstone balls; then 10½ fathoms of shales, interbedded with hard flaggy sandstones or "faikes." Some of these beds are hard, others soft, with intervening beds of argillaceous shale—the "blaes" of the borer. Next, a series of limestone beds and calcareous shale, 14 fathoms thick, different from any strata gone through in the west of the central valley or in the north of Ayrshire, so far as I know. After passing through 4 fathoms of thin-bedded limestones and calcareous shales, varying from 6 inches to 5 feet thick, the bore went through the following:—

	FT.	IN.
Hard limestone, good,	9	2
Calcareous shale,	1	6
Limestone, good,	7	11
Calcareous shale,	2	6
Limestone, good,	4	4
Calcareous shale,	9	4
Limestone, good,	7	0
Calcareous shale,	2	8
Limestone, good,	12	0
Calcareous shale,	0	6
Limestone, good,	1	0
Argillaceous shale,	4	4
Limestone,	2	8
	64	11

I was at first inclined to put these down amongst the calciferous strata, thinking that they might be the equivalents of some of the limestones found in this group on the east side of the central valley. But I am now of opinion that this great thickness of limestone belongs to the lower limestone series, and probably lies above the main post and coal, of the Howwood, Duntocher, Campsie, and Hurlet horizon, which has not been bored to at this point. We have, however, nothing corresponding to these limestone strata in the above districts. A similar series exists in the north of Ayrshire, in the neighbourhood of Beith, but, except in this particular, there is no resemblance between the strata of the two districts. Whatever the position, the basin containing this

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thickness of limestone is of small extent, as three bores put down along the outcrop of the dolerite to the north of Paisley, on the farm of Gallowhill, did not find it. According to these, the dolerite rests, along this line, upon a series of thick-bedded shales, fire-clays, and sandstones, which have been bored into for a depth of more than 30 fathoms. Accepting these beds as overlying the main limestone, I have thus provisionally placed the dolerite, as stated, somewhere between it and the clayband ironstone strata.

With these explanations, and returning to the quarry at Seedhills as the starting point, I will endeavour to trace the dolerite bed, noticing the openings in it as we go along. It has here been extensively quarried, being cut into from west to east, across the strike, for about 150 yards. It is here, as elsewhere along this tract of country, a surface stratum, although deeply covered by a deposit of boulder clay, and has been long worked for paving-stones and other road-making purposes. A ridge of inferior stone passes through the centre of the quarry, running north and south; but is of no great geological value, further than that it causes a small anticlinal, which has preserved two very interesting sets of glacial striæ. Leaving Seedhills, and following the dolerite bed towards the south, the strike is found for a short distance to have a south by east direction, but here the ground is so built over that its traces are lost. After leaving the houses and gardens, the practised eye soon picks up its course, and, following what in appearance is a wavy ridge, finds the bed again laid bare as it crosses the Cart, near Blackhall printfield. On the south side of the river the water has laid bare about two poles of the dolerite, and it is here seen to be lying at a greater inclination to east by south of 15°, which is the direction and dip of the strata in connection. From its outcrop on the south bank of the Cart the strike is in a direction south by west, the edge of the dolerite rising from 20 to 30 feet above the level of the surrounding country, and dipping to the south-east at an angle of 20°. On the south bank of the river is seen, overlying the dolerite, about 60 feet of shale, with thin bands of clay ironstone, one of them being 6 inches thick. Over the shale lies the Blackhall limestone, 4 feet thick, in three thin beds, which have been worked at this place.

Along the west side of the dolerite strike there is a deep cutting which puzzled me considerably for some time, and which I may explain for the benefit of those members who may visit the locality.

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It is a long narrow gully, beginning on the west side of the dolerite outcrop near the Cart, and continuing in the same direction as the outcrop, across a field where the dolerite rises high above the surface. It crosses the Blackhall Road, and is seen following the dolerite across Dikebar Hill, the strike having here turned southward. I saw from the first that it was artificial, having the appearance of a heavy railway cutting, but no one could give me any information about it. At last I was directed to two old men living in the vicinity, and they supplied the missing link. An outlier of the Blackhall limestone had run along the west side of the dolerite in a long narrow stripe, and had been taken out by my aged informants' father above sixty years ago. This information was interesting as testifying to the fact that the dolerite, which is not again seen as a surface stratum, continues along Dikebar Hill, having been found along the east side of the limestone outlier when it was excavated. From the direction of the gully the dolerite strike turns to the south-west; and, although I have not seen the connection, not having examined it very minutely, I have no doubt there is a connection with the north-east end of the Gleniffer range, which is not far distant. Overlying the dolerite at Blackhall there are about 6 feet of strata not found at Seedhills, consisting of thin beds of anamesite, a few inches thick, and intercalated ash, much fired and indurated. At one place above the true dolerite, and resting upon it, is a layer 4 inches thick, resembling a miniature bed of columnar basalt, but very much burnt.

Returning to Seedhills, and continuing northwards, the strike has a north-east direction till near the Arkleston tunnel, where it turns more to the north. At the tunnel the dolerite becomes a surface bed, and rises with an escarpment about 30 feet above the ground level to the west of it. The dip here is to the south-east, at an angle of 5°, and the thickness of the bed, which can easily be obtained at present, is 24 feet. The railway at the west end of the tunnel cuts into the underlying strata about 18 feet, consisting of the hard black indurated shale or nondescript beds formerly mentioned, found on the farm of Gallowhill. The coarse hard sandstone found at Seedhills does not extend here. From the tunnel the dolerite bed is seen extending towards Arkleston House, the strike being north by east, and still rising above the land surface with an escarpment of 30 feet. It passes on in the same direction, cropping

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out on the west side of the powder-house, which, as well as Arkleston House, is founded upon it. North of the powder-house it has been extensively quarried for road-making purposes. It then takes a bend nearly north-east, and continues for half-a-mile, easily traceable by the practised eye as a continuance of the Arkleston escarpment, although it makes no surface appearance, and the land is under cultivation. From this point we lose all trace of the bed until we reach Elderslie House, which is founded upon it. It then crosses the park between the house and the Clyde, in the bed of which it appears, as is known to all Glasgow geologists and others interested in the river.

By a letter from Mr Deas, engineer to the Clyde Trust, I learn that the dolerite bed occupies the channel of the stream for about 300 yards in length, thus proving that it is lying at a very small angle of inclination, probably not more than two or three degrees. Had it passed at the same angle as it has when crossing the Cart at Blackhall, it would not have obstructed the course of the Clyde for more than 40 yards, or even less, and would have saved a vast amount of labour and expense in its removal. Mr Deas also remarks that its upper surface in the river is 16 feet below high water mark, showing that from Elderslie House the dip is nearly north, while the inclination is apparently regular at about 5°. Passing to the north bank of the Clyde, I failed to find any surface appearance of the dolerite bed, but was told that it extended northward, passing to the west of Blawarthill farm-house. The tenant here was my informant, and he also told me that the Clyde Trust had put down three bores on his farm, at regular distances, extending northward from the river. The bed was found in all the bores, but each bore proceeding north was deeper than the previous one. As the surface land lies nearly level where these bores were put down, there is clear proof that the dip continues in the same direction. As the farmer saw the bores put down, and was paid damages by the Clyde Trust for the use of his ground, I consider his evidence perfectly trustworthy, especially as it quite agrees with what we know of the regular dip north, on the south side of the river. I could not ascertain the exact depth of the bores, but the most northerly one was said to be about 50 feet. It must not be inferred that the dolerite bed is such a depth below high water mark at this point. From the rise of the land near the Clyde, I think the upper surface of the bed,

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about one mile north of the river, is not more than 25 to 30 feet below high water mark. After this all trace of it is lost; but I must admit that the search has not been carried on very vigorously, and I have little doubt that a more exhaustive investigation will be rewarded by its discovery farther to the north. There is one very significant feature in a belt of country where the strike and outcrop of the dolerite bed should occur, which is the absence of pits. The same occurs in the line of country between Paisley and Renfrew. No pits are there to be found on either side of the bed, for the reason that the Lower Carboniferous strata are thrown up and the ironstone is thrown off. Whether this applies to the north side remains to be seen.

In bringing these remarks to a conclusion, I may state that I had intended to notice a few more of the lava flows to be found in Renfrewshire, and which prove that active volcanoes existed, probably in some part of the Gleniffer hills, during the Carboniferous period. At present, however, I will only mention one other dolerite bed, that which crosses from the Gleniffer range, and passes the village of Sclates, three miles west of Paisley, near which place it was quarried a few years ago. Thence it runs in a north-east direction, passing near Paisley race-course. Its horizon, so far as I have learned, is almost the same as that of the subject of my paper. Another extensive overflow is found overlying the Quarrelton and Hallhill coal, and extends from near the village of Elderslie almost to Howwood, with a strike nearly east and west. At one place it was found to be above 300 feet thick, while at Hallhill, near its western extremity, its thickness is 80 feet. This bed does not extend very far northwards. From one to two miles from the Gleniffer hills, with which it appears to have a connection, is its present known extremity. Other beds of small dimensions are found intrusive in the Carboniferous strata in the same locality.

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[ABSTRACT.]

XXI.—RECENT RESEARCHES *into the* HISTORY *of the* DEPOSITS *known as* OLD RED SANDSTONE. By Prof. GEIKIE, F.R.S., etc.

[Read 24th January, 1876.]

AFTER a preliminary outline of our present knowledge on the subject, Prof. Geikie proceeded to consider the development of the Old Red Sandstone in the British Isles under its accepted threefold division into Lower, Middle, and Upper. The Lower member, wherever its true base can be seen, is found to pass down conformably into the Upper Silurian rocks. But a well-marked line of demarcation, both by physical characters and fossil evidence, runs between the two systems. The Silurian formations continue replete with organic remains up to their uppermost zone; but on entering the red strata of the overlying system we meet with a remarkably abrupt change, for the fossils almost wholly disappear, and those which occur belong for the most part to fishes and crustaceans. The author pointed out the geological evidence in favour of great terrestrial oscillations, as explained by Prof. Ramsay, whereby the bed of the Silurian sea in our area came to be raised into land with wide lakes and inland seas. He showed that the beginnings of the movements which led to those results could be traced back a considerable way into the Silurian period, that over large tracts the Silurian deposits had been upraised before the close of that period, and that the oscillations continued during the accumulation of the Lower Old Red Sandstone, as indicated by the coarse conglomerates, the great mass of the deposits, and the unconformabilities traceable in them. Recent detailed work of the Geological Survey has brought to light the fact that this lower division of the Old Red Sandstone attains an almost incredible thickness. In Lanarkshire and Ayrshire Mr B. N. Peach has found it to measure 15,000 feet. In Perthshire, from the combined surveys of Mr Peach and Mr R. L. Jack, it has been ascertained to reach a depth of more than 19,000 feet. But the author has found that traced eastward into Forfarshire and Kincardineshire, its thickness rises above 20,000 feet. And yet in no case is its top actually seen, since it has either been removed by denudation, or buried under some more recent uncon-

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formable formation. Nor is its base to be found, since along the flank of the Grampians a great fault runs from the North Sea at Stonehaven to the estuary of the Clyde, with the effect of throwing the strata of the Old Red Sandstone on end, sometimes for a distance of two miles from the line of the dislocation. The amount of displacement must be in some places not less than 5,000 feet, as indicated by the position of occasional outliers of conglomerate on the Highland side of the fault. One of the most striking features in the formation is the enormous development of its contemporaneous volcanic rocks. These are underlaid in Kincardineshire by about 5,000 feet of sandstones and shales, and they pass under the grey flags and conglomerates of Forfar and an upper series of red and purple sandstones. They consist of thick sheets of various porphyries with beds of tuff and enormous masses of coarse volcanic conglomerates. Zones of grey flagstones, including the well-known beds of Carmylie near Arbroath, are intercalcated in them. In the Ochil Hills, according to the measurements of Mr B. N. Peach, this volcanic zone reaches a depth of not less than 6,500 feet. It runs from the sea-coast at Dunottar, through the chain of the Sidlaw and Ochil Hills, to near Stirling. It reappears south of the Forth, in the Pentland chain, and stretches south-westwards in great force across Lanarkshire and Ayrshire. The author then alluded to the fossils hitherto noticed in this part of the Old Red Sandstone in different parts of Britain, pointing out the contrast they present to those of the preceding Silurian rocks. He showed that in Forfarshire the well-known crustaceans and fishes had been obtained from strata, lying, not as hitherto supposed at the base of the system, but several thousand feet higher, and that the fish-bed found by Mr Mitchell in Kincardineshire, and supposed by Sir Roderick Murchison to indicate from its Acanthodian forms an approach to the middle Old Red Sandstone, really lay below the position of the Turin flagstones so well explored by Mr Powrie.

The so-called "Middle" Old Red Sandstone is not known certainly to exist anywhere else in Britain than in the north of Scotland. This subdivision was introduced by Sir R. Murchison, and is based wholly on the evidence from fossils. It presents a remarkably distinct series of ichthyolites, which have not been met with in the Lower Old Red Sandstone of the south, and which have therefore been held to mark a higher series of deposits. The

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"Middle" Old Red Sandstone is typically developed in the well-known flags of Caithness. Those strata, long since described by Sedgwick and Murchison, cover nearly the whole of that county, and stretch into the Orkney and Shetland Islands. The author had measured a section of these on the east coast of Caithness more than 8,000 feet in thickness. They show conglomerates and red sandstones at the base, and similar strata reappear on different higher horizons. But on the whole, the series consists of dark-grey, hard, fine-grained flagstones, sometimes bituminous, often calcareous, and frequently abounding in remains of fishes, entomostraca, and land-plants. No evidence of contemporaneous volcanic action has yet been met with in these rocks. The general character of the whole series differs in many respects from that of the Old Red Sandstone on the south side of the Grampians, and appears to indicate widely different conditions of deposit. The basins in which the Caithness flags and the Arbroath flags accumulated, were separated by the intervening mass of the Inverness-shire and Aberdeenshire highlands, as shown by the basement conglomerates on each side of the mountains. The author then dwelt on the fossil evidence and its bearings. He suggested that it could not be held to prove a "Middle" series, and that it was not inconsistent with the idea that the Caithness flags really belonged to the Lower Old Red Sandstone, the peculiarities of their fauna not being greater than might be due to great differences of physical geography, and to the fact that the respective areas of deposit were isolated from each other. He further pointed out that some of the most characteristic forms of the lower group occur in the Caithness and Orkney beds, *e.g.*, *Parexus* and *Pterygotus*. The Caithness flags abound in land-plants like *Sigillaria*, *Lepidodendron*, and some of the peculiar Devonian forms found by Dr Dawson in Gaspé. Some of these latter forms have recently been detected by Mr R. L. Jack in the course of the work of the Geological Survey in Perthshire.

The red and yellow sandstones, red clays, and red conglomerates and breccias, included under the term "Upper Old Red Sandstone," are copiously developed in Wales, in Ireland, and in the south of Scotland. In the two last-named regions they have been shown to lie unconformably on all older formations, there being a complete physical discordance, and an entire difference in organic contents, between these strata and the Lower Old Red Sandstone.

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In South Wales a less marked break in the series may be suspected from the cautious descriptions given by Sir Henry De la Beche. In the north of Scotland Sir R. Murchison has described the Upper as graduating downwards into the Middle or Caithness flags. In Caithness itself, however, and in Orkney, they are completely discordant, and the same relation may be inferred to hold elsewhere. This uppermost member thus bears the same relation to the Caithness flags as to the Arbroath flags. Wherever the top of the series can be seen, it is found to pass gradually and conformably into the base of the Carboniferous system. So thoroughly do those two series of deposits dovetail with each other that no sharp line can be drawn between them. If we work our way into the red rocks from the Carboniferous side, we may claim them as merely the base of the Carboniferous system. If we approach them from the side of the Old Red Sandstone, we may well regard them as a late and unconformable sub-division of this system.

The author next adverted to the fossils peculiar to the Upper Old Red Sandstone, calling attention to the continuance of land-plants and ganoid fishes as characteristic Old Red Sandstone features. He then, in conclusion, pointed out the physical geography which appears to be indicated by the deposits of this period. It is still possible to map out some of the terrestrial and lacustrine areas which then marked the site of Britain. Hill-ranges, still in existence, formed prominent features in the land-scapes of that time, though with many differences of outline; in particular, with water-filled bays, straits, long fjord-like inlets and scattered lakes, which have been filled up with sandstones, conglomerates, and breccias. The red stain of these deposits, occasional pseudomorphs of rock-salt and layers of gypsum, combined with ripple-marks and sun-cracks seem, as Prof. Ramsay has suggested, to indicate the concentration of the saline waters which filled these basins; while further evidence of the unwholesome nature of the water may be indicated by the general paucity of fossils in the strata, and by the immense numbers of well-preserved fishes which are sometimes met with crowded into a small space, as if they had come from fresher water elsewhere, and had been inclosed and killed in scattered pools. The peculiar breccias and brecciated conglomerates of the Upper Old Red Sandstone have been compared to some recent glacial deposits,

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and the resemblance has been pointed out between the form of the stones in these deposits and those in common boulder-clay. It should be noted also that in many cases these breccias occur in old valleys, and bear many of the characters of valley-moraines. Such are those to the east of Ullswater, and those which flank, and in some places penetrate the Lammermuir Hills. In the latter district worn dome-shaped bosses of rock underlying the breccias recall the aspect of true *roches moutonnées*. Another glacial feature is suggested by the basin-shaped hollows (apparently sometimes true rock basins) in which the deposits lie. Further indications of ice are given by the remarkable patches of angular and rounded stones scattered through the red sandstones of Arran, the occurrence and position of which may be accounted for on the supposition that they are portions of shore-gravel, which have been frozen and transported in cakes of floating-ice.

Indications of terrestrial disturbance during the accumulation of the Upper Old Red Sandstone in Scotland are furnished by the Lammermuir Hills. At the close of the period, and thence through the deposition of the Lower Carboniferous rocks, volcanic action, which seems to have been quiescent for a long interval, broke out again over the south of Scotland. To this period belongs the chain of old lavas and tuffs which may be traced from the mouth of the Nith eastwards by Langholm and the Tarras Water to the head of the Slitrig Valley, and through the plain of the Tweed as far northwards as the Whiteadder. The Garlton Hills, Campsie Fells, and the ranges of hills which run down Renfrewshire and the north-east of Ayrshire, and are prolonged into Bute, the Cumbrays, and Arran, mark a prolonged series of volcanic eruptions during this same epoch. Traces of contemporaneous volcanic action occur likewise in the Upper Old Red Sandstone of the north of Scotland, and form a remarkable feature in the cliffs of Hoy, one of the Orkney Islands.

The author brought forward evidence to show that while the Upper Old Red Sandstone was being deposited in the British area, there existed outside that area a sea in which some of the characteristic corals, brachiopods, and other organisms of the time of the Carboniferous Limestone, already existed. He pointed out the intercalation of limestone bands in the red sandstone series in Arran and elsewhere, a long way below the base of the cement-stone group which underlies the Carboniferous Limestone. These

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calcareous bands, full of species of fossils which are familiar in the Carboniferous Limestone, seem to indicate that while, on the whole, the Upper Old Red Sandstone, and the red strata at the base of the Carboniferous system, were deposited under conditions unfavourable to the presence of at least corals, crinoids, and molluscs, their formation was interrupted by intervals during which clearer and less saline water prevailed, perhaps owing to the removal of barriers which allowed the access of the main ocean, with its animal forms, into the closed lagoons and inland seas of the Upper Old Red Sandstone.

XXII.—Notes *on a* Post-tertiary Deposit of Shell-bearing Clay *on the west side of the Railway Tunnel* at Arkleston, near Paisley. By David Robertson, F.L.S., F.G.S.

[Read 9th March, 1876.]

This deposit was first brought under my notice by my friend, Mr Robert Craig of Beith, who has already described its physical features at a recent meeting of the Society. I need not, therefore, take up time in going over that which was so well done, further than by stating a few of the general facts necessary to elucidate what I have to say. The shell-bearing deposit is about 40 feet above sea-level, and lies in the same relative position to the boulder-clay and upper drifts as it generally does throughout Scotland. In this case the area of the exposed shell bed is overlaid by a foot or two of sandy mould. Mr Craig thinks that the sand and gravel at this point had been removed at some former time for economic purposes, as on the south side of the railway, abutting on the rock of the tunnel, is a bed of fine sand, 10 feet thick, which again is overlaid by a bed of gravel nearly of the same depth. Both these beds are laminated, but I have not found shells in either. This, however, is but negative, and furnishes little proof against the former presence of shells, as clean sand is a bad preservative of fossil remains, unless indeed it is impregnated with foreign matter, such as lime or iron. It may be remarked that the sands and gravels, which involve considerations of much intricacy, are not peculiar to this deposit, in which they are confined to a small area thinning off towards the north, but

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are generally found to a greater or lesser extent overlying all our post-tertiary clays. Whatever the agencies that have laid them down in the order we now find them, or whatever their source, they represent an enormous amount of tear and wear of the earth's surface. For we must bear in mind that quartz sand, such as is to be found here, is but a fraction of the great bulk of which it once formed a part, having withstood the excessive trituration which ground the less hard portions into impalpable mud, and from which it has been separated by the action of water. This is all the more obvious when we consider how very small the proportion of quartz rock is, compared with the other rocks of our country. The shell-bearing clay here is sandy, and more or less distinctly laminated, following in a great measure, so far as I could see, the incline of the trough in which it rests, and without doubt belonging to the shell-bearing clays of the Clyde district. The shells found in it are all marine, and are generally in a fair state of preservation; for though much broken, and in some cases eroded, they are not water-worn. On very slight examination it will be found that they are of a mixed character, that is, they belong to shallow as well as to deeper water, though the prevailing shells are littoral, such as *Littorina littorea*, *L. obtusata*, and *Mytillus edule*, together with *Corallina officinalis*, a seaweed confined exclusively to the littoral zone, or shallow water. This littoral character is further borne out by the crustacean ostracods, especially by the excessive abundance of the species *Cytherura nigrescens*. Though frequently found in greater depths, even to 50 fathoms, yet between high and low water mark is the habitat of this species, and there only is it met with in profusion. There is another littoral species belonging to the same order, *C. castanea*, which is moderately common and in good condition in this deposit, but therefore the more remarkable, as, on the authority of Mr Brady in his monograph on Recent British Ostracoda, it is chiefly an inhabitant of the brackish water of estuaries and salt-marshes. It is found in great abundance and in beautiful condition in brackish lagoons skirting the bay of Westport in Ireland. It is also met with, under apparently purely marine conditions, in the Firth of Clyde, where it occurred in 15 gatherings out of 40, at depths of from 1 to 26 fathoms. But these were mostly in lochs, or in other places where fresh water might have an influence, and it prevails most where that influence is most decided. There are here a few

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other species of shells, common both to brackish and fresh-water conditions, but there is undoubtedly a great preponderance of purely marine species. It cannot, therefore, be admitted to be a brackish water deposit; but it is possible that at some time or other brackish water conditions may have existed for a time, or the brackish living species may have been derived from some adjoining localities favourable to their existence. The littoral mollusca are found nearly from the top to the bottom of the deposit, but are most abundant in layers at various distances. The deeper water shells, which include Arctic species, as *Pecten Islandicus* and *Tellina calcaria*, appear to lie between the boulder-clay and the clay containing the littoral shells. This was most clearly seen close to the boulder-clay, near where it crops out on the north bank of the railway. Unfortunately, at the time of my visit the cutting was so disposed that I could not examine the lower layers containing the Arctic shells along the deepest part of the section, in order to see whether they continuously contained shells whose natural habitat is at greater depths than those that overlie them. Although this could not be seen satisfactorily, yet, when we know that the exposed portion of the upper deposit is crowded with littoral shells, it becomes evident that the two sets of shells belong to different deposits, and that those of the deep and those of the shallow water lived at different periods, and that between each period the land and water held different relations. It may be suggested that the deep water shells, which are comparatively few and fragmentary, may have been thrown up from deeper water. In answer to this, it must be remembered that, although much broken, these shells are not water-worn, nor are the fractured edges in any way abraded, and many of them still retain the epidermis, from all which we may reasonably infer that they lived and died where they are found. That odd shells from the older deposit may be found washed up amongst the littoral forms is only what we might expect, and that there may be a partial mixing at the line of junction is just as likely; but such things in no way interfere with the main facts of the case. The question comes up, Was the elevation of the land slow and gradual? In that case we would expect to find littoral shells spread over the whole of the post-tertiary clays of Scotland; yet, although we make allowance for the enormous work of denudation, there appears to be no good evidence that such was the case. On

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the other hand, that the elevation was more or less spasmodic we have good ground for supposing, from numerous old sea beaches in our own neighbourhood. Many of these appear to have been determined from tracks of abrasion (independently of proof from fossil remains), which leaves doubt in many cases whether these terraces were formed in lake margins or cut along old coast lines by littoral waves, or by some other agencies that rounded off hill tops, planed and groved mountain sides, and cut long deep troughs in the hardest rocks; but in those belts of littoral shells there can be no question of the pre-existence of a shallow sea-shore, while from the great abundance of littoral shells, there can be little doubt that the upper and greater portions of the deposit at this place formed a shore-belt long subsequent to the life history of the underlying deeper water shells. These littoral belts, which are found occurring at different heights in the valley of the Clyde, where no indications of our old shore line are seen further than the presence of the shells, lead us to believe that pauses in the elevation of the land may have been more frequent and of shorter duration than our well-marked 20 feet and 40 feet old sea-beaches would lead us to suppose, but yet sufficiently long to allow of the colonisation of a considerable littoral fauna at these intervals. There can be little doubt that overlapping or mixing of older and newer deposits will be more commonly found than we have hitherto supposed to be the case; and in this way many of the anomalies that have presented themselves, where a profusion of both littoral and deep water shells have been found together, may be satisfactorily accounted for. In such cases the line of demarcation between the older and newer deposits will be more or less obscure and intricate in proportion to the extent they have been subjected to the action of water, which is clearly indicated by the overlying masses of sand and gravel. In the present case, although the fossil remains have not been collected under favourable conditions, from the excavation being partly covered over before we saw it, and owing to the few opportunities we had of seeing it afterwards, still, the prevailing organisms have been ascertained which, almost in every case, give a special character to the deposit.

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VERTEBRATA.

Two bones.

MOLLUSCA.

CONCHIFERA.

Anomia ephippium, Linné.	Rare and small.
Pecten Islandicus, Müller.	Moderately rare.
Mytilus edulis, Linn.	Common; large and small; mostly broken.
——— *modiola*, Linn.	Moderately common.
Nucula tenuis, Montagu.	Rare.
Leda pernula, Müll.	Moderately rare.
—— *pygmæa*, Munster.	Moderately rare and small.
Axinus flexuosus, Mont.	Moderately common.
Cyprina Islandica, Linn.	Moderately rare; large valves with epidermis.
Tellina calcaria, Chemnitz.	Common; small.
Mya truncata, Linn.	Rather rare.
Saxicava rugosa, Linn.	Rather rare.

GASTEROPODA.

Chiton, sp.	Two plates.
Puncturella Noachina, Linn.	Rare.
Trochus Grœnlandicus, Chemn.	Rare.
Lacuna divaricata, Fabricius.	Common.
——— *petiolus*, Fabr.	Rare.
Littorina littorea, Linn.	In great abundance.
——— *obtusata*, var. *neritiformis*, Linn.	Moderately common.
——— *limata*, Lovén.	Common.
——— *rudis*, Maton.	Rare.
Rissoa striata, Adams.	Common.
—— *parva*, var. *interrupta*, Adams.	Very common.
Skenea planorbis, Fabr.	Moderately common.
Homalogyra atomus, Phillips.	Rare.
Natica affinis, Gmelin.	Moderately common.
——— *Grœnlandica*, Beck.	Moderately rare.
Cerithium reticulatum, Da Costa.	Moderately rare.
Buccinum undatum, Linn.	Moderately common; large and small.
Trophon clathratus, Strömer.	Moderately common; large and small.
——— ———, var. *Gunneri*, Lovén.	Rare.
——— *truncatus*, Ström.	Moderately rare.
Pleurotoma pyramidalis, Ström.	Moderately rare.
——— *violacea*, Mighels and Adams.	Moderately rare.
Utriculus mammillatus, Phill.	Moderately common.
——— *obtusus*, Mont.	Moderately rare.

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POLYZOA.

Discoporella Grignoniensis, Milne Edwards.	Rare; a Crag fossil.

CRUSTACEA.

CIRRIPEDIA.

Balanus crenatus, Brug.	Very common and characteristic.
——— *Hameri*, Ascanius.	Rare.
——— *balanoides*, Linn.	Common.
Verruca Strömia, Müll.	Rare.

Plates and claws of Crabs, too fragmentary to determine.

OSTRACODA.

Cythere lutea, Müll.	Very abundant, and in good condition.
——— *angulata*, Sars.	Moderately common.
——— *concinna*, Jones.	Moderately common.
——— *villosa*, Sars.	Moderately common.
——— *tuberculata*, Sars.	Common; male and female.
——— *castanea*, Sars.	Common; male and female; in very fine condition.
——— *porcellanea*, Brady.	Common.
——— *viridis*, Müll.	Common, and in good condition.
Eucythere Argus, Sars.	Rare.
Cytheridea punctillata, Brady.	Rare and poor.
——— *papillosa*, Bosquet.	Moderately common.
Loxoconcha tamarindus, Jones.	Common.
——— *fragilis*, Sars.	Moderately rare.
Cytherura undata, Sars.	Common.
——— *nigrescens*, Baird.	Very abundant; young, and full grown.
——— *Sarsii*, Brady.	Moderately common.
——— *clathrata*, Sars.	Rare; very fine.
Cytheropteron latissimum, Norman.	Common.
——— *nodosum*, Brady and Robertson.	Rare.
Sclerochilus contortus, Norman.	Common.
Paradoxostoma variabile, Baird.	Moderately common.

ECHINODERMATA.

Spines and plates too imperfect to determine.

ZOOPHYTA.

Eudendrium rameum, Pallas.	Rare.

FORAMINIFERA.

Quinqueloculina seminulum, Linn.	Common.
——— *subrotunda*, Montagu.	Moderately common.

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Lagena sulcata, Walker and Jones.	Rare monstrosity.
——— *distoma*, Parker and Jones.	Rare.
Polymorphina lactea, W. and J.	Moderately common.
Globigerina bulloides, D'Orbigny.	Rare, and very weak.
Truncatulina lobatula, Walker.	Rather rare.
Polystomella striato-punctata, Fichtel and Moll.	Very common.
Nonionina depressula, W. and J.	Rare.

PLANTÆ.

Rootlets incrusted with clay.	Rather common.
Corallina officinalis, Linn.	Fragments; common.

XXIII.—*On the* STRATIFIED ROCKS *of the* GARPEL WATER, MUIRKIRK, AYRSHIRE. By JAMES THOMSON, F.G.S., member of the Royal Science Society, Liege, Belgium.

[Read 9th March, 1876.]

IN order that my subject may be better understood, I propose to take a preliminary glance at the stratigraphical position of the rocks found in the strath, from Glenbuck on the east to Ballochmyle on the west. At the eastern extremity of Glenbuck, where the water for Catrine Mills is collected, and before it enters the Water of Ayr, the rocks belong to the Upper Silurians. Overlying them is a thin bed of Old Red Sandstone, which again is overlaid by Lower Carboniferous strata, these latter to be seen abutting against, and flanking the Old Red Sandstone all round the lower or western end of Glenbuck. The Carboniferous rocks fill in and form the centre of the valley, and the low blackband ironstone which is seen cropping out on either side has been wrought for a considerable period, and is still being worked at various depths nearly to Auchinleck on the west. In the Greenock Water, on the north side of the valley, the upper rocks are seen overlying breccia, which in turn overlies a series of argillaceous shales, more or less chocolate coloured, with the pale yellowish concretionary limestone which characterises this horizon of Upper Old Red. Similar sections are seen all along the north bank of the Ayr Water, except at Ballochmyle, where there is a great fault. There the deep-red Permian rocks are seen in juxtaposition to the upper limestones of the Scottish coalfields. The dislocation

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is well seen at Lugar, at which place the rocks can be studied and classified. Farther east, on the south side of the strath, and on the banks of the upper reaches of the Garse Water, the lower members of the mountain limestone have been extensively quarried. Indeed, wherever there is a stream, on either side the rocks are exposed to advantage. In the Garpel Water, however, they are better seen than elsewhere, that stream being larger than any of the others, even the Ayr Water, of which, though a so-called tributary, it is in reality the main stream.

A branch of the South-Western Railway passes up the south side of the valley, from Auchinleck to Muirkirk, and the foundations of the bridge carrying it across the Garpel Water are built upon a close-grained, compact, light-blue limestone, which is the equivalent of the Linnspout limestone of Dalry. In this rock we find certain fossils characteristic of this horizon. Conspicuous amongst these is *Rhynchonella pugnus*, Martin; also *Orthis resupinata*, Martin, and *Streptorynchus crenistria*, vars. *senilis*, Phillips, and *robusta*, Hall, frequently found at Bowertrapping, near Dalry; these latter not yet having been discovered in any other horizon of Carboniferous strata. There are also various forms which, although found in a state of preservation peculiar to these beds, are met with in other parts of the formation, and throughout all the lower members of the Carboniferous beds, such as *Spirifera trigonalis*, var. *bisulcata*, Sowerby; *Strophomena rhomboidalis*, var. *distorta*, J. de C. Sowerby; and *Productus scabriculus*, Martin. This latter form seems to have been in greater abundance in this horizon than in many of the previous deposits, and has attained larger dimensions than in any other section of Carboniferous limestone. There are also *P. latissimus*, J. de C. Sow.; *P. semireticulatus*, Martin; *P. punctatus*, Martin; *P. longispinus*, Sow.; *P. aculeatus*, Martin, with many other organisms belonging to the same horizon. This limestone overlies a bed of sandstone of considerable thickness, resting upon a calcareous shale which is seen to pass from lacustrine to marine conditions. The shale passes by imperceptible gradations into impure limestone, in which *P. latissimus* is found developed to an extent peculiar to this section. This limestone is found in various other parts of Scotland—in the Marsh, Dalry; at Auchenbeg and Bellfield, Lesmahagow; and usually contains *P. latissimus*. The other forms found in it are

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not in a good state of preservation, so it would appear that owing to the greater thickness of this shell it has been able to withstand the abrading influences which have affected others. Overlying this limestone is a bed of calcareous shale of considerable thickness. The section has long been exposed to the influence of the weather, and is consequently weathered and eroded so that the deposits cannot be seen in their normal condition. In this shale is found the interesting encrinite *Platycrinus lævis*, Miller, which has a remarkable ridge passing across the centre, and parallel with the long axis of the stem. This crinoid attracted the attention of that ever memorable observer, the Rev. David Ure, and was figured in his "History of Rutherglen and East Kilbride," 1793. It has also been figured and described as occurring in Belgium, by Prof. de Koninck, in his "Recherches sur les Animaux Fossiles." The shale in question, in parts highly fossiliferous, is exposed in other localities, *e.g.*, to the east of the North British Railway on the road from Kilsyth to Castlecary; at Swindridge Muir, in the parish of Dalry; and at Auchenbeg, three miles to the south of Lesmahagow.

The section in the district I am now describing is seen passing along the face of the rising ground south-east of the Muirkirk railway station, and overlies a thick bed of sandstone which has been quarried a short distance east of the ironworks: several thin bands of coal have there been rendered columnar by intrusive sheets of felstone, which are finely exposed in the face of the quarry. The sandstone forms a more or less elevated ridge, well seen in the Garpel Water. Underlying it is a bank of bituminous shale, which may be seen passing insensibly from impure coal, first into shale, then into arenaceous shale, and lastly, into the sandstone above referred to. The junction may be readily traced by the synclinal trough along the country, and more especially near the Garpel Water, continuing up it for a considerable distance. There is a pit quite close to the little waterfall there, and in sinking the shaft they passed through the sections just noticed. The low main coal was found 52 feet under the sandstone; and overlying the coal a bed of calcareous shale, in which occur the largest specimens of *Lingula mytiloides*, Sow., that I have ever seen in British strata, several measuring an inch in length: I also discovered various forms which seem to have lived in estuaries of the Carboniferous sea. Indeed, in these

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passage beds we may trace a gradual transition from lacustrine conditions into estuarine, passing into the marine conditions of the old seas in which the limestone was formed. It is seen cropping out on the banks a little way farther up the stream. Farther up in the same direction are to be found beds everywhere characteristic of this section of Carboniferous strata—alternate representatives of lacustrine, marine, and estuarine deposits, with here and there inter-stratified thin beds of coal, until we reach the lower members of the period, in which may be found the organic remains usually met with in the same horizon throughout Scotland. Most conspicuous are the excellent examples of *Productus giganteus*, Martin, showing both the ventral and dorsal valves, in which state it is extremely rare. I also procured here specimens in which the interior muscular impressions are preserved in a perfect state.

Underlying these deposits are thick beds of calcareous shales, which pass into the breccia and dull red sandstone so characteristic of this horizon. These are succeeded by the grey, chocolate-coloured shales which everywhere distinguish the passage beds between the Carboniferous and the Old Red deposits. Interstratified with these are several thin beds of concretionary limestone of a dull white or creamy colour, in which I found a group of small *Producti* much resembling the young of *P. giganteus*. Not finding any with the internal structure, I could not with certainty fix the species; but as they are true Carboniferous fossils, there is little doubt that these are passage beds between the Lower Carboniferous rocks and the underlying Old Red sandstone. Similar beds have not been recorded as occurring in England, and this is the first time, so far as I am aware, that passage beds containing marine fossils have been noted as occurring in Scotland. I have, however, discovered marine conditions in the parish of Lesmahagow in the same horizon of strata as the above.

In proceeding farther up the Garpel Water we pass over marls, sandstones, and the breccia so frequently found in the upper members of the Scottish Old Red sandstone. All of these are seen folding round the flank of Cairntable, and can be studied to great advantage in the Garpel Water, in the upper reaches of which we leave its winding course and ascend the hillside to the south. Having gained the top we find, as in most of the prominent ridges of Scotland, the igneous rocks which have

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upraised the stratified rocks, and have, by the upheaval, produced those folds and plications which distinguish the central valley of the country, and which have, in my opinion, been attributed rather hastily to the action of ice alone. Indeed, observation should teach us that we cannot afford to ignore the action of an agent which is well known to alter and modify the surface configuration of extensive tracts of the earth's surface of the present day, as doubtless it did in the past. I am persuaded that if there were fewer dogmatic assertions made by incautious observers, there would not be so many stumbling blocks placed in the path of knowledge. But let us combine stratigraphical evidence with palæontological facts, and then only can we hope to arrive at anything like a satisfactory explanation of the phenomena of the mighty past.

This short digression has led us from our immediate subject. We have gained the top of that ridge of hills which bounds the south side of the valley. Let us now descend through Glenmuirshaw, down which flows a small stream running westward, and entering the Lugar a short way above Cumnock. The sections here are concealed by the overlying vegetation for a considerable distance towards the south-east; but in a little rill about halfway down the hillside the stratified rocks are again seen, consisting of sandstone, and shales both calcareous and lacustrine. Here and there are thin beds of limestone, in which I got a remarkable variety of *Productus*, resembling in outline a member of the same genus which I found in abundance in the grand section which rises cliff above cliff about 1400 feet high, at the beautiful village of Llangollen, in North Wales.

From this point the stratified rocks are occasionally seen until we reach the main valley. We now turn to the left and ascend the bed of a small burn, which, running from east to west, has cut its way into the rocks, exposing on either side most excellent sections of the lowest beds of Carboniferous sandstone, which pass into the breccia of the period, and overlie the chocolate-coloured marls above referred to. We then reach an extensive mass of igneous rock and tufa, more or less amygdaloidal, and in one portion somewhat augitic in character. Some of the amygdaloids have all the characteristics of our finest Scottish pebbles, whilst others partake of an intermediate variety between them and the sardonyx, others again being true sardonyx. The day is now

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far spent, and our bags are filled to overflowing; even every pocket is crammed, so we turn our faces to the hillside, put a stout heart to a stey brae, trudge across the muir, and reach Muirkirk in time to catch the last train for home.

XXIV.—Garnock Water Post-tertiary Deposit. By David Robertson, F.L.S., F.G.S.

[Read 30th March, 1876.]

It is with pleasure that I refer to the frequency with which deposits of shell-bearing clays have been brought under my notice, and often those which were not likely to have been otherwise heard of; if the value of such information were more generally known, there can be little doubt that many important additions to our knowledge would be secured. In the present instance I am indebted to Mr John Smith, Kilwinning, but my obligations to him are greatly increased by his kind and valuable assistance, not only in accompanying me to the place, but by providing implements and labour which enabled us to examine effectually a mass calculated to be not less than 30 cwt. of the material. This may appear to be a large amount to examine in part of a day, but the deposit was unusually favourable for such an operation, being chiefly composed of muddy sand, and lying on the bank of a stream in which it washed easily through large fine sieves, while the shells were retained in a beautifully clean condition.

The shell bed is exposed in a scaur on the south bank of the Garnock, about two hundred yards to the south-east of Kilwinning iron works, the bank being about twenty-two feet above the level of the sea. The layer containing the shells is ten or twelve inches thick, and about six feet above the level of the stream, which was very low at the time of our visit. The shell-bearing clay rests on boulder-clay, and is overlaid by 12 feet of stratified sand and gravel, which thins out as it reaches a little way up the stream, but dips and increases in thickness towards the south-east; and is not seen here on the opposite bank. Mr Smith informed me that shell beds have been met with in other

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cuttings and borings in the neighbourhood, particulars of which may throw some light on the bearings of the bed I now speak of.

The shell-bearing clay at this place consists of—

Fine mud	12 per cent.
Fine sand	52 „
Coarse sand	16 „
Shell debris and gravel . . .	20 „

The shells as a whole are in good condition, and agree closely in general character with those of the Dalmuir and Old Mains deposits, which stand about the same level above the sea—Dalmuir, on a small tributary of the Clyde, Old Mains, a little way off the Cart.

All these deposits are largely made up of sand, and all three contain *Velutina undata* (Smith), which is a highly northern species, and rarely met with in the Clyde beds. It inhabits the Arctic seas of both continents, and is fossil in the Mammalian Crag at Bramerton, Uddevalla, and in Canada. What makes its occurrence in the Garnock deposit more remarkable, is its abundance and fine condition. I procured above 30 specimens, and Mr Smith at sundry times has secured probably double that number.

Another curious point of similarity between the Garnock and Dalmuir beds, is that they both contain numerous winged, fluted, and knobbed spines of Echini, which have rarely come under my notice in any other deposit. It may be difficult to account for the vagaries the spines of these animals assume in particular localities.* The Echini plates as well as the spines are very abundant, and from their abrupt curves it is seen that the animals have been mostly of small size. The erosion on some of the plates shows that peculiar ornamentation met with in a few of the post-tertiary beds, both of Scotland and Norway. Amongst other parts of Echinodermata, *Pedicellaria* are plentiful. In all, 106 species have been obtained from this bed, which are classed as follows:—*Mollusca*, 44 species; *Polyzoa*, 2; *Crustacea*, 31; *Annelida*, 2; *Echinodermata*, 2; *Foraminifera*, 23; *Porifera*, 1; and *Plantæ*, 1.

* May it not be alleged that these irregular processes along the spines are survival indications of some long lost character?

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MOLLUSCA.

CONCHIFERA.

Anomia ephippium, Linné.	Common; all small.
Pecten Islandicus, Müller.	A fragment only.
Mytilus edulis, Linn.	One small valve.
——— *modiolus*, Linn.	Moderately common.
Nucula, *sp.*	Rare.
Leda pernula, Müll.	Moderately common; small.
—— *pygmæa*, Münster.	Rare and small.
Axinus flexuosus, Montagu.	Very common.
Cardium edule, Linn.	Two valves.
Astarte borealis, Chemnitz.	Rare.
——— *compressa*, Mont.	Common.
Tapes virgineus, Linn.	One imperfect valve.
Tellina calcaria, Chemn.	Common.
Scrobicularia alba, Wood.	Rare and small.
Mya truncata, Linn.	Moderately common, some with the siphon preserved.
Saxicava rugosa, Linn.	Moderately common and large.

GASTEROPODA.

Chiton marmoreus, Fabricius.	Common.
Helcion pellucidum, Linn.	Rare; small.
Tectura virginea, Müll.	Very common.
Puncturella Noachina, Linn.	Common.
Trochus cinerarius, Linn.	Moderately rare.
——— *tumidus*, Chemn.	Very common.
——— *Grœnlandicus*, Chemn.	Moderately rare.
Lacuna divaricata, Fabr.	Rare.
Littorina littorea, Linn.	Rare.
——— *rudis*, Maton.	Rare.
——— *obtusata*, Linn.	Rare.
Rissoa striata, Adams.	Common.
—— *parva*, var. *interrupta*, Adams.	Common.
Skenea planorbis, Fabr.	Moderately rare.
Homalogyra atomus, Phill.	Moderately common.
Natica affinis, Gmel.	Moderately common.
——— *Grœnlandica*, Beck.	Rare.
Velutina undata, Smith.	Common, and in fine condition.
Cerithium reticulatum, Da Costa.	A fragment.
Buccinum Grœnlandicum, Chemn.	Moderately rare; much eroded.
——— *undatum*, Linn.	Small.
Defrancia, *sp.*	Rare.
Trophon clathratus, Linn.	Common.
——— ——— var. *Gunneri*, Lovén.	Rare.

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Pleurotoma pyramidalis, Strömer.	Moderately common.
——— *violacea*, Mighels and Adams.	Rare.
——— *turricula*, Mont.	Rare.
Utriculus obtusus, Mont.	Moderately common.

POLYZOA.

Membranipora Flemingii, Busk.	Rare.
Lepralia cruenta, Norman.	Rare.

CRUSTACEA.

CIRRIPEDIA.

Balanus porcatus, Da Costa.	Common and large.
——— *crenatus*, Brug.	Rare; very small.
Verruca Strömia, Müll.	Moderately common.

Crab claw.

OSTRACODA.

Argillœcea cylindrica, Sars.	Rare.
Cythere gibbosa, Brady and Robertson.	Moderately common.
——— *lutea*, Müll.	Common.
——— *concinna*, Jones.	Very common.
——— *angulata*, Sars.	Common.
——— *tuberculata*, Sars.	Common.
——— *castanea*, Sars.	Rare.
——— *porcellanea*, Brady.	Rare.
——— *pellucida*, Baird.	Moderately common.
——— *tenera*, Brady.	Rare.
——— *viridis*, Müll.	Common.
——— *villosa*, Sars.	Rare.
——— *pulchella*, Brady.	Rare.
Cytheridea punctillata, Brady.	Common.
——— *papillosa*, Bosquet.	Common.
Eucythere Argus, Sars.	Moderately common.
Loxoconcha tamarindus, Jones.	Moderately common.
Cytherura clathrata, Sars.	Moderately common.
——— *undata*, Sars.	Very common.
——— *striata*, Sars.	Common.
——— *cornuta*, Brady.	Rare.
——— *Sarsii*, Brady.	Moderately common.
——— *nigrescens*, Baird.	Common.
Sclerochilus contortus, Norman.	Moderately common.
Paradoxostoma variabile, Baird.	Rare.
——— *Fischeri*, Sars.	Rare.
——— *ensiforme*, Brady.	Moderately common.

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ANNELIDA.

Spirorbis spirillum, Linn.	Rare.
Serpula vermicularis, Ellis.	Moderately common.

ECHINODERMATA.

Echinus Drōbachiensis, Müll., Plates and spines.	Common.
Starfish plates.	Rare.

FORAMINIFERA.

Cornuspira foliacea, Phill.	Rare.
Biloculina depressa, D'Orbigny.	Rare.
Triloculina trigonula, Lamarck.	Rare.
——— *oblonga*, Mont.	Common.
——— *Brongniartii*, D'Orb.	Rare.
Quinqueloculina seminulum, Linn.	Common.
——— *bicornis*, Walker and Jones.	Rare.
——— *subrotunda*, Mont.	Common.
Lagena sulcata, W. and J.	Rare.
——— *marginata*, Mont.	Rare.
——— *caudata*, D'Orb.	Rare.
Polymorphina oblonga, Brown.	Rare.
——— *lactea*, W. and J.	Rare.
Orbulina universa, D'Orb.	Rare.
Globigerina bulloides, D'Orb.	Moderately common.
Bulivina punctata, D'Orb.	Rare.
Discorbina rosacea, D'Orb.	Rare.
Planorbulina Mediterranensis, D'Orb.	Rare.
Truncatulina lobatula, Walker.	Common.
Rotalia Beccarii, Linn.	Rare.
Polystomella striato-punctata, Fichtel and Moll.	Moderately common.
Nonionina depressula, W. and J.	Moderately rare.
——— *asterizans*, F. and M.	

PORIFERA.

Cliona celata, Grant.

PLANTÆ.

Melobesia polymorpha, Linn.	On stones and shells.

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XXV.—Notes *on the* Post-tertiary Deposit *of* Misk Pit, *near* Kilwinning. By David Robertson, F.L.S., F.G.S.

[Read 19th January, 1877.]

As at Garnock Water, this deposit was brought under my notice by Mr John Smith, Eglinton Iron Works. I am also indebted to him for the journal of the bore; besides which, while superintending the sinking of the pit, he secured samples of the shell-bearing clays from the various strata as they were passed through, with that accuracy which is at all times of so much value.

Misk Pit is a little to the south-west of Kilwinning, about three-quarters of a mile from the sea-shore, the mouth of the shaft not being much above high water-mark. The ground on the south-eastern side is comparatively flat, forming an area of several square miles in extent; and hundreds of acres are protected from the inundations of very high tides by the drifted hills of shore-sand and by the artificial bankings of the rivers. It may be mentioned here, that along the banks of the Irvine at different points, both above and below the town, marine shells of an old sea-beach are exposed. The same bed has been cut into at different places, at considerable distances inland, at a depth of from 10 to 12 feet from the surface, the overlying material being chiefly sand.

The strata passed through in sinking the pit, so far as connected with our present remarks, were as follows:—

Surface soil,	1	foot.
Sand,	2	feet.
Gravelly sand,	7	„
Muddy sand, with thin bands of dark vegetable mud,	18	„
Sandy clay,	3	„
Clay, with less sand,	2	„
Fine clay, consisting of brown and reddish brown layers,	2	„
Boulder-clay, with large scratched boulders,	3	„
Boulder-clay, with bands of gravel, resting on shale,	4	„

It will be noticed that this bore has not passed through the stratum of shells of the old raised beach. Different bores

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at no great distance from each other show that the sand is very irregular in depth, at some places attaining a thickness of 60 or 70 feet. As this large accumulation of sand appears to lie under the old sea beach, it is presumably a marine deposit rather than drifted sand. In regard to the drifting sand in this locality, it is to be observed that it is making rapid encroachments from year to year on the neighbouring arable land—the sand has been seen covering the snow to a depth of seven inches—and those most conversant with the facts of the case believe that at no distant date many miles of the district will be laid waste, if better means than have hitherto been devised are not discovered to stay its progress.

In the section of a tramway leading to the pit, a stratum of vegetable mould, about 12 inches thick, was seen in the sand, running along the cutting; the depth of the overlying sand varying, of course, with the hummocks of drifted sand. This layer of mould appears to have been a growth of vegetation over the sand of a receded sea, and which in its turn has been covered by drifted sand. If produced from plants grown on the spot, we may infer that a considerable time elapsed during its formation, and before the drifting of the sand began to set in over it.

In passing through the upper 10 feet of surface soil, sand, and gravelly sand, we came to the 18 feet of muddy sand, with thin bands of vegetable mud about an inch in thickness, averaging about a foot apart. It was in the lower half of this 18 feet portion that shells and other organisms were met with in the greatest abundance. The first shell noticed (*Littorina littorea*) was at a depth of 19 feet from the surface, or exactly in the middle of the 18 feet of muddy sand. At 22 feet from the surface, shells and other organisms were frequent, but the species of shells were few, *Tellina calcaria* being most prevalent. At from 22 to 28 feet, *T. calcaria* was still the prevailing shell; and what was most remarkable connected with its occurrence in this deposit, was its unusually large size, larger than any we have hitherto met with in our Scottish clays, the specimens generally measuring over $1\frac{6}{16}$ in. by $1\frac{2}{16}$ in., and some of the broken shells obviously indicating even larger sizes. In this part of the section *Astarte sulcata*, var. *elliptica*, was moderately common and large, together with a few valves of *Astarte borealis*, which were also above the common size. *Cyprina Islandica*, *Pecten Islandicus*, and

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others, as will be seen by the general list, were common. In the next two layers—the one of sandy clay and the other clay with less sand, at a depth of from 28 to 33 feet from the surface—shells were still abundant and large, with more species and more univalves. The remaining part of the shell-bearing section consisted of the 2 feet of very thin layers of alternating red and brown clay. In this portion all the large shells were absent, only small sized species being found, as *Leda pygmæa*, two or three specimens of *Rissoa striata*, one small *Natica Grœnlandica*, and a few species of Ostracoda and Foraminifera which were common in the upper parts of the section containing shells.

The shell that bulks most largely in the deposit is *Cyprina Islandica*, next is *Pecten Islandicus*, and the species which is most numerous individually is *Tellina calcaria*, the next being *Astarte sulcata*, var. *elliptica*. Bivalves predominate greatly over univalves, particularly in the upper portion of the section. In this respect the bivalves and univalves of this pit approach the relative distribution of those on the east coast more than those on the west of Scotland, as univalves are characteristically rare in the eastern clay beds. This coincidence, however, is no guide in either a geographical or geological point of view, as these changes frequently depend on strictly local circumstances. For example, about a mile or so to the east of this pit, a deposit occurs on the Garnock Water, most likely a continuation of the same bed, being similar in composition (muddy sand) and resting in the same way on boulder-clay and overlaid by sandy gravel.* In it the univalves predominate over the bivalves both in species and individuals. *Cyprina Islandica* and *Astarte sulcata*, var. *elliptica*, were not found, and with the exception of one small fragment, the same may be said of *Pecten Islandicus*—all these bulking so largely in the Misk Pit. In the Garnock section, *Tellina calcaria* is of smaller size than that species is usually met with in the clays on the west of Scotland, while those found in the Misk Pit are greatly larger.

It is at all times a matter of interest when a rare form is met with; but when a common shell of the district is wholly absent from any particular deposit, although a circumstance not likely to attract attention, yet it must be in all cases suggestive of some peculiar condition of that deposit. *Axinus flexuosus* is one of the

* See paper on Garnock Water Post-tertiary Deposit, page 292.

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common shells of the Clyde district, yet only a fragment of it has been detected in Misk Pit. Again, on the other hand, we have the little shell *Eulima distorta*, not only new to the district, but, so far as I know, new to Britain as a post-tertiary fossil. Sars enumerates this species as a post-glacial fossil, from a shell bank in Norway 50 feet above the sea level. In our present seas it is a widely diffused species from low water to great depths.

Another feature in the deposit at Misk Pit is the presence of extensive sheets of *Melobesia polymorpha*, spread over the boulders. Some of the stones are covered more or less with a thin smooth incrustation; others have the covering of a tuberculous or mammalated appearance. This alga is common in the Clyde shell-bearing clay-beds, but I have never seen it to the same extent as here. Harvey gives its habitat as common on littoral rocks all round our coasts, extending beyond low water mark. It may be likewise remarked that the stones in the clay in this pit are more covered with animal and vegetable growths than they usually are in our clay deposits. This large stone, you will observe, is crowded all round the edges with *Serpulæ*, *Spirorbis*, and Polyzoa, and at one end they overlap part of the upper surface, the underside obviously having been protected by the bottom on which it lay, while the free part on the top was probably shielded by some overlying stone. You will notice that the upper side of the stone has a smooth and rubbed appearance, and is closely scratched with irregular striæ, which, there can be no doubt, took place before its location in the clay of the pit; and as the *Serpulæ* overlie the striations, they are, of course, a subsequent production. Had the grinding agency which scratched the stones operated upon them in the position where they are found, there would have been decided evidence of the same action on the associated shells; but no such evidence is found, not a scratch or polish from abrasion having been seen on one of them. At the same time, there may be a question whether all the organisms attached to the stones grew in the position where they are now found, or whether the stones may have been transported hither with the organisms on them.

The *Melobesia* and *Serpulæ* are chiefly sub-littoral species, while the shells that prevail in this bed are of a deeper water character, which favours the prevailing opinion that stones, with their

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parasites, under such circumstances, are mostly derivatives, having been taken up by shore ice and dropped where they are found. This becomes more evident from the fact that *Balani* are occasionally found in the clay-beds on the under side of the stone, imbedded in the mud; and this is inconsistent with the habit of these animals, which, whether on the upper or lower side of the stone, must have a free flow of water. In other cases, the horizontal girdle of *Balani*, or other organisms frequently met with on stones, corresponding with the surface of the mud in which the stones had been imbedded at the time the organisms took possession of them, is now often found standing vertical to the stratification of the clay in which they are at present imbedded. That the stones have been transported and placed under other conditions since the formation of the encircling girdle of *Balani* is obvious, from the absence of another girdle crossing the first, as there can be no reason to doubt that a new colony of *Balani* would soon have attached themselves to the stones, had they only been turned up and left with the same surroundings.

Chalk Flints in Laminated Clay.—This flint nodule, from the Misk Pit, which I now hand round, was met with at a depth of 24 feet. It weighs fully 15 oz., and is nearly as broad as long, rounded at the top and flat at the bottom. The fracture seen on the under side was done at the pit-head, but other smaller flint nodules, deeper in the deposit, together with small water-worn stones, were found fractured, which must have been the result of considerable pressure at some stage of their history, and this we can scarcely suppose to have taken place in the soft muddy sand in which they were found. Flints do not appear to be common in the clays on the West of Scotland; I have only found another piece, which was likewise imbedded in the clay with Arctic shells, on Inch Lonaig, Loch Lomond.

On the east and north-east of Scotland they have been much more frequently met with. Professor Fleming* mentions the occurrence of a fragment of chalk flint upwards of an ounce in weight at Tirie, near Kirkcaldy, in a clay field with Arctic shells, *Leda truncata* of Brown, *Leda arctica* of Gray.

Another section occurs on the coast of Aberdeen, at Belhelvie,† in a deposit of laminated clay resting on the ordinary boulder-clay,

* "Lithology of Edinburgh," p. 77. † Ibid, p. 79.

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and overlaid by the usual sands and gravels. The deposit is about 40 feet above high water mark, and contains fragments of coast shells, and amongst them some entire valves of *Panopea Norvegica*, *Pecten Islandicus*, and *Tellina (proxima) calcaria*, together with chalk flints and angular blocks of hard and soft chalk as large as one's hand.

Mr James Bennie informs me that he found in "West Clay-field," Portobello, a small bit of chalk, 1½ in. by 1 in., in a parting of sand 30 feet below the surface, and which contained abundant sponge spicules. It is now in the Geological Museum of Edinburgh. Since that time he has found other pieces of chalk in the same clay-field, some of the pieces being several inches in length, and one or two being marked with striæ. In one piece bands of flint, a quarter of an inch in thickness, occurred, running through the chalk. Pieces of greenish clay were likewise met, mottled with white spots. When these spots were cut out and washed, they were found to contain Ostracoda and Foraminifera abundantly, with numerous crumbs of chalk and a few of flint. The workmen stated that pieces of flint were occasionally met with in the deposit.

Mr Bennie further informs me that he got a piece of chalk in a clay-field near Kirkcaldy, 3 in. by 2 in. by 1 in., and found that it was almost entirely made up of Foraminifera. In the laminated shell-bearing clays at Elie he met with crumbs of chalk, and Mr James Geikie, who mapped the drafts, states, in the work copies of the district, that he found nodules of flint in the Elie beds.

In the laminated clay at Puggeston tile work, near Montrose, large and small pieces of hard chalk are plentiful, chiefly about 8 or 9 feet below the surface, which was the depth of the section at the time of my visit. These pieces of chalk gave the lower band quite a speckled appearance. So far as I can remember, none of the chalk was scratched or water-worn.

Flints in Boulder Clay.—Mr Peach informs me that he finds flints in the boulder-clays all over Caithness. His paper in the "Transactions of the Royal Physical Society," Vol. iii., p. 396, gives many other interesting particulars.

Flints spread over the surface.—Mr Peach says,* "When walking across the north side of the Island of Stroma, I was surprised to

* "Transactions of the Royal Physical Society," Vol. ii., p. 159.

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find chalk flints in considerable abundance on the surface wherever I went, even on the ploughed land; and where the vegetation was not too thick, I met with flints varying in size from a boy's marble to 8 or 10 inches over. The flints are slightly water-worn; with them are blocks of granite, gneiss, and smaller pieces of hornblende, reddish conglomerate, quartz, etc. I passed over Pentland, and whilst my horse was feeding and being got ready for my return, I took the opportunity of looking round 'John o'Groat's,' and there chalk flints were to be seen, but not in that abundance as at Stroma."

Prof. Fleming, in his "Lithology of Edinburgh," page 77, says:—"After a good deal of ripple action by east wind, I detected large patches of chalk flints at the Black Rocks (Leith); and Mr Christie of Hawkhill has observed them in considerable abundance on a field to the eastward of the house" (one mile N.E. of Edinburgh).

Mr Jamieson states that an extensive bed of chalk flints covers the top of a low moory ridge for six or seven miles near Peterhead, and also the top of Windyhills, near Fyvie, and the top of another ridge near the town of Turriff, and considers that these are the remains of pre-glacial deposits. None of these flints, so far as I know, have been found in the true boulder-clay.

Though the deposits of clay of Caithness have gone under the name of boulder-clay, it has obviously been laid down under different conditions from that of the true boulder-clay or till, the Caithness clay containing marine organisms of many different orders, genera, and species, from bottom to top, while the true boulder-clay or till is almost destitute of life remains of any kind. On looking over the list of flints on the east and west of Scotland, it will be seen that all those in the laminated clays are associated with marine organisms, and are in most cases intermixed with Arctic forms.

Now, if the laminated shell-bearing clays have been formed, as they are generally supposed to have been, chiefly by a re-wash of the boulder-clay, and if we may reasonably assume that the boulder-clay is the detritus of the pre-glacial covering (including flints with other pebbles) of the surrounding country, then we should expect to find flints, wherever they occur, more abundant in the boulder-clay than in the overlying laminated clay, which is not the case. Therefore, whatever course the flints in our

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laminated clays have taken in transportation, there seems no reason to think that they have been transmitted through the boulder-clay. That they are ice-borne there can be little doubt. Some of those found on the surface in the Island of Stroma, by Mr Peach, were water-worn, and striated pieces of chalk were found by Mr James Bennie in the laminated clays of Portobello; as to their source there is considerable difference of opinion. Prof. Fleming indicates Denmark; others suggest the north-east coast of Ireland, but in that case we should expect to find the flints more abundant in the clays of the west than in those of the east of Scotland, which is quite the reverse of the fact. But from whatever source they may have come, the question is greatly widened when we take into account the occurrence of flint nodules in the strata alternating with the Miocene leaf beds of Mull.

The fossils obtained in the Misk Pit deposit were—

Mollusca,	39	species.
Polyzoa,	8	"
Crustacea,	37	"
Annelida,	2	"
Echinodermata,	3	"
Foraminifera,	45	"
Porifera,	1	"
Plantæ,	1	"
In all,	136	species.

It is not, however, the number of species found in any deposit that is of the greatest interest. When we know what species prevail, thereby indicating the main character of the deposit, the addition of a species or two to the already large number can be of no great value. What is of most interest, in a geological point of view, is the condition of the organisms relatively to those of other deposits or to those of surrounding seas, whether they are larger or smaller, rarer or more abundant; or the occurrence of a species peculiar or new to the beds in which it is found.

One of these waifs, *Eulima distorta*, before referred to, occurs in Misk Pit, and, although of wide distribution, and common in our surrounding seas, this is the first time, so far as I know, that it has been found in our post-tertiary clays; its occurrence, here at least, proves its co-existence in our Scottish seas at that time.

This may be coupled with a case of still more interest,

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the occurrence of *Trochus lineatus*, moderately common in a raised beach in Cumbrae, and not now found in the neighbouring seas. Although common in England, Wales, and the west and south of Ireland, it is doubtful whether it has been found as a recent shell in Scotland, though reported by Smith at Cumbrae, by MacGillivray at Peterhead, and by Capt. Laskey at Dunbar. These were taken by the dredge in less or more deep water. Laskey's find was one specimen in deep water; the details are not given by the others, but as the habitat of the species is on rocks just below high water mark, these examples were not likely to be alive. Smith's find was obviously washed out from the old sea-beach referred to, and there are strong reasons to suppose that the others were from similar sources. The species inhabits the north of France, and Santander in the north of Spain, so Scotland may be presumed to have been its northern limits. It is a matter of some interest to consider what has been the probable cause of its removal from its northern boundaries; its habitat being rocks near high water, it could not have been from any change of sea bottom.

In conclusion, I may remark that although the 18 feet of muddy sand in the Misk Pit is intercalated from top to bottom with thin bands of vegetable matter, no doubt brought down by periodical floods of the river Garnock, there has not been a vestige met with of fresh-water or brackish-water forms, which are generally found in all estuarian deposits.

This may be so far explained by the fact that at Greenock, where the strength of the current of the Clyde passes the harbour, fresh or brackish water forms are common, but over on the Row side, which is quite out of the current, not a brackish water form is found. That the Garnock did bring down organisms from the higher reaches, we have proof of in the little land shell, *Cochlicopa tridens*, which was found in this deposit. Its occurrence here is all the more remarkable, as it appears to be a rare shell in Scotland, having only been recorded by Dr Fleming, on the authority of Capt. Laskey, who is said to have found it in the Carline Park, near Leith. It is also in the collection of the Hunterian Museum, being found a few years ago by Mr Foulis in the neighbourhood of the Bridge of Allan, and noted in the Transactions of the Natural History Society of Glasgow, Vol. i., p. 240. Although this little shell can now

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claim to be contemporaneous with the glacial period of this country, it can boast of a still higher antiquity, being a descendant of the fossils of the Upper Tertiaries.

MOLLUSCA.

CONCHIFERA.

Anomia ephippium, Linné.	Moderately common.
Pecten Islandicus, Müller.	Common.
Mytilus edulis, Linn.	Rare; large.
——— *modiolus*, Linn.	Rather rare.
Nucula tenuis, Montagu.	Rather rare.
Leda pernula, Müll.	Rather rare.
———, var. *mucilenta*, Steenstrup.	Rather rare.
—— *pygmæa*, Munster.	Very common; small.
Axinus flexuosus, Mont.	Moderately rare.
Cardium fasciatum, Mont.	Moderately common.
Cyprina Islandica, Linn.	Common; large.
Astarte sulcata, var. *elliptica*, Brown.	Common; large.
——— *borealis*, Chemnitz.	Moderately common; large.
——— *compressa*, Mont.	Common.
Tellina calcaria, Chemn.	Common; large.
Scrobicularia prismatica, Mont.	Rare; small.
Mya truncata, Linn.	Rather rare.
Saxicava rugosa, Linn.	Rather rare.

GASTEROPODA.

Chiton marmoreus, Fabricius.	Moderately common.
Tectura virginea, Müll.	Moderately common; rather small.
Puncturella Noachina, Linn.	Rare; fragmentary.
Trochus tumidus, Mont.	Rare.
Mölleria costalata, Möller.	Rare.
Littorina littorea, Linn.	Rare.
——— *rudis*, Maton.	Rare.
——— *limata*, Lovén.	Rare.
Rissoa striata, Adams.	Moderately rare.
——— *parva*, var. *interrupta*, Adams.	Rare.
Odostomia unidentata, Mont.	Rare.
Eulima distorta, Deshayes.	Rare.
Natica affinis, Gmelin.	Rare.
——— *Grœnlandica*, Beck.	Moderately common.
Buccinum undatum, Linn.	Rare.
Trophon clathratus, Linn.	Rare.
——— *truncatus*, Strömer.	Rare.
Fusus antiquus, Linn.	Rare; young.

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Pleurotoma turricula, Mont.	Moderately rare.
Utriculus obtusus, Mont.	Moderately common.
———, var. *Lajonkaireana*.	Rare.

POLYZOA.

Cellularia reptans, Linn.	Rare.
Menipea ternata, var. Ellis and Solander.	Rare.
Membranipora craticula, Alder.	Moderately common.
Lepralia Peachii, Johnston.	Rare.
——— *tubulosa*, Norman.	Rare.
Crisia eburnea, Linn.	Rare.
Discoporella Grignoniensis, Busk.	Rare.
——— *flosculus*, Hincks.	Rare.

CRUSTACEA.

CIRRIPEDIA.

Balanus balanoides, Linn.	Rare.
——— *crenatus*, Brug.	Moderately common.
——— *porcatus*, Da Costa.	Common; large.
Verruca Strömia, Müller.	Moderately common.

OSTRACODA.

Argillæcia cylindrica, G. O. Sars.	Moderately rare.
Cythere pellucida, Baird.	Common.
——— *castanea*, G. O. Sars.	Moderately rare.
——— *porcellanea*, Brady.	Rare.
——— *lutea*, Müll.	Common.
——— *limicola*, Norman.	Common.
——— *concinna*, Jones.	Common.
——— *tuberculata*, G. O. Sars.	Common.
——— *angulata*, G. O. Sars.	Common.
——— *Dunelmensis*, Norman.	Moderately common.
——— *viridis*, Müll.	Rare.
——— *emarginata*, G. O. Sars.	Rare.
Cytheridea Sorbyana, Jones.	Rare; hitherto only found on the west coast at Tangy Burn, but common in the clay beds of the east coast.
——— *punctillata*, Brady.	Common.
——— *papillosa*, Bosquet.	Common.
Eucythere Argus, G. O. Sars.	Rare.
Loxoconcha tamarindus, Jones.	Common.
——— *impressa*, Baird.	
Cytherura clathrata, G. O. Sars.	Rare.
——— *angulata*, Brady.	Rare.
——— *undata*, G. O. Sars.	Moderately rare.
——— *Sarsii*, Brady.	Moderately common.

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Cytherura nigrescens, Baird.	Common.
——— *striata*, G. O. Sars.	Moderately common.
Cytheropteron latissimum, Norman.	Moderately common.
——— *Montrosiense*, Brady, Crosskey, and Robertson.	Rare.
Bythocythere simplex, Norman.	Moderately common.
——— *constricta*, G. O. Sars.	Rare.
Sclerochilus contortus, Norman.	Moderately rare.
Paradoxostoma variabile, Baird.	Rare.
——— *flexuosum*, Brady.	Rare.
———, *sp.*	Rare.
Polycope orbicularis, G. O. Sars.	Rare.

ANNELIDA.

Serpula vermicularis, Ellis.	Moderately common.
Spirorbis spirillum, Linn.	

ECHINODERMATA.

ECHINOIDEA.

Echinus Dröbachiensis, Müll., Plates & spines.	Moderately rare.
Starfish plates and spines.	2 species.

SPATANGIDÆ.

Plates and spines.

FORAMINIFERA.

Cornuspira foliacea, Phill.
Biloculina ringens, Lamarck.
——— *affinis*, D'Orbigny.
——— *elongata*, D'Orb.
——— *depressa*, D'Orb.
——— *carinata*, D'Orb.
Triloculina Brongniartii, D'Orb.
——— *tricarinata*, D'Orb.
Quinqueloculina seminulum, Linn.
——— *secans*, D'Orb.
——— *agglutinans*, D'Orb.
——— *Ferussacii*, D'Orb.
——— *subrotunda*, Mont.
Lituola Canariensis, D'Orb.
Lagena sulcata, Walker and Jones.
——— *lævis*, Mont.
——— *striata*, D'Orb.
——— *semistriata*, Williamson.
——— *apiculata*, Reuss.
——— *distoma*, Parker and Jones.
———, var.
———, var.

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Lagena globosa, Mont.
——— *caudata*, D'Orb.
——— *marginata*, Mont.
——— *squamosa*, var. *hexagona*.
Dentalina consobrina, D'Orb.
Cristellaria rotulata, Lam.
Polymorphina compressa, D'Orb.
——————— *oblonga*, Brown.
——————— *gibba*, D'Orb.
Globigerina bulloides, D'Orb.
Textularia variabilis, Will.
Verneuilina polystropha, Reuss.
Bulimina marginata, D'Orb.
——— *pupoides*, D'Orb.
——— *ovata*, D'Orb.
Virgulina squamosa, D'Orb.
Bolivina punctata, D'Orb.
Discorbina globularis, D'Orb.
Planorbulina Mediterranenses, D'Orb.
Truncatulina lobatula, Walker.
Rotalia Beccarii, Linn.
Polystomella striato-punctata, Fichtel and Moll.
Nonionina asterizans, F. and M.

PORIFERA.

Cliona celata, Grant. Moderately common.

PLANTÆ.

Melobesia polymorpha, Linn. Very common.

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PROCEEDINGS FOR THE SESSION 1874–75.

29TH OCTOBER, 1874.

ANNUAL BUSINESS MEETING.

Mr E. A. WÜNSCH, *Vice-President*, in the Chair.

Mr D. BELL, Secretary, read the Report for the preceding year, of which the following is a summary:—

MEMBERSHIP.—The number of ordinary members on the roll is equal to the average of several of the Society's most prosperous years. The Council have again to remark on the increase of what may be termed the "fluctuating margin"—the number leaving or ceasing to be members from year to year. They would therefore again urge upon the friends of the Society the necessity of renewed exertions, especially at the commencement of the Session, to increase the membership so as to make allowance for such changes, and that the Society may be maintained both financially and in other respects. The Council deem it very desirable not only that the income of the Society should suffice to meet its ordinary expenditure, but also that a surplus of some amount should be available for the purchase of important Geological Books, Memoirs, and Essays, from time to time, and also for purposes of research connected with the Geology of the West of Scotland.

ORDINARY MEETINGS.—These secured an average attendance during the Session, and the papers read embraced a variety of topics both of local and more general interest. While the Council express their continued obligations to those members of the Society who have frequently brought forward papers, they would express the hope that some of the younger members may also be induced to take part in this branch of the Society's work. Some of the corresponding members have again to be thanked for contributing valuable papers.

The SPECIMENS exhibited were of considerable interest, and their examination and comparison proved, as usual, one of the most instructive features of the Society's proceedings.

The ELEMENTARY LECTURES were not resumed last Session, for the same reason as that given in last report, viz., in consideration of the excellent course of Lectures delivered in the Mechanics' Institution. The Council have much gratification in observing the interest in Geology which these lectures have been the means of diffusing, as shown by the number of new members which the Society obtained from amongst those who attended the course referred to. As is well known to the Society, Mr M'Master, a former

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member of your Council, and one of the Vice-Presidents of the Mechanics' Institution, who is now in Canada, took a special interest in this department, and was the means of bringing forward many accessions to the membership. The Council therefore beg to record their sense of the value of his services.

Excursions.—These, the Council are happy to state, were well attended, and were found to be of much interest and benefit to the members. The localities visited were High Blantyre, Giffnock, Corrieburn, Beith, and Craigenglen, as also a special excursion on the Queen's Birth-day to Killearn and the Blane Valley. The Council record their obligations to Messrs. Glen, Dewar, Young, Craig, and Dairon, who conducted the several excursions; also, to Mr James Thomson, F.G.S., for his valuable assistance on several occasions.

Museum.—Amongst other donations to the Museum during the past year, has been a valuable collection of rocks and fossils from Canada, forwarded through Mr Archd. Robertson, by Mr A. R. Selwyn, F.G.S., Director of the Geological Survey of Canada, to whom the Council have duly transmitted their acknowledgments.

The Library continues to be largely made use of, particularly during the Session, by the members; and the thanks of the Society are again due to Mr Richard Neilson, for kindly continuing his services as Librarian. The want of additional accommodation has been increasingly felt, and this the Council hope to remedy at an early date. A friendly correspondence and interchange of publications is maintained with numerous Societies in Great Britain and abroad, and the Transactions and Memoirs, thus regularly received, form a most useful portion of the Library.

Transactions.—As was intimated by circular, the Third and concluding Part of Vol. IV. was issued during the summer Session. Some of the papers, which will form the first Part of Vol. V., are now in the press, and it is hoped the Part will be published in January next.

The Council regret that, owing to Professor Geikie's engagements otherwise, he has not yet been able to overtake the revision of his memoir on the Glacial Drift, as promised last year, but hope that it will be in hands before another Session.

The Council trust that the Session which is now opened will show no diminution in the zeal of the members, nor in the interest attaching to the proceedings; and they hope to receive, as hitherto, the cordial co-operation of all the members and office-bearers in carrying on the work, and in extending the influence of the Society.

Mr John Wight, C.A., Treasurer, read the financial report for the year, (see abstract on page 336), after which the report was duly approved of.

The Chairman said that before proceeding further with the business of the evening, he had a very pleasing duty to discharge. As many of the members were aware, one of their Vice-Presidents, Mr John Young, who had long been identified with the Society, had been lately appointed Lecturer

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on Geology to the Mechanics' Institution. It seemed, therefore, to some of Mr Young's friends, both in this Society and beyond it, to be a fitting occasion to testify in some way their respect for him, and their good wishes for the work in which he was about to engage. The movement had been singularly spontaneous and cordial, and the result was that he had now the very great pleasure, in the name of the subscribers, of presenting to Mr Young the articles before him—namely, a diploma of Life Membership of the Geological Society of London, an elegant aneroid barometer, and a purse of sovereigns. He requested Mr Young's acceptance of these as a token of the appreciation in which the services he had rendered, not only to this Society, but to the science of geology, were held, and of the hope and expectation which were entertained that his labours in communicating to others what he so well knew himself would be abundantly successful.

Mr Young made a feeling and suitable reply.

Mr David Sandeman, chairman of the Mechanics' Institution, expressed the pleasure he had in being present to witness what he would call an act of simple justice, not only to Mr Young, but to themselves, and his confidence that, as a teacher of the science, Mr Young would be of the greatest service to the Institution in which he was about to labour.

Mr D. Corse Glen, C.E., exhibited some specimens of iron ores and also of rock salt from the north of Ireland. The iron ores were from the works of the Larne Iron Ore Mining Company at Shanes or Craigiehill, about five miles from Larne, County Antrim. The mines are worked by a level into the side of the hill, known in western Scottish coal-mining as an "ingaun' e'e." The top bed is the richest, and is of a greenish grey colour, with small black nodules—hence called Pisolitic iron ore; it has an average thickness of 2½ feet, contains about 40 per cent. of iron, and is very free from sulphur and phosphorus. The second bed is inferior in quality, varies in thickness from five to seven feet, and contains about 23 per cent. of iron. These two upper beds are worked together, and the ores mixed. The third or lowest bed, called Lithomarge, is from 20 to 30 feet thick, but is of very poor quality, containing only about 12 per cent. of iron. It has more the appearance of coloured clay, soon falling into dust on exposure to the weather, and is only useful as a flux in smelting some of the richer hematite ores. These ferruginous beds which he had described occur interstratified through the basaltic rocks of the district, and are considered to be the result of the decomposition of trappean surfaces during the intervals between the successive volcanic eruptions. The greater part of all these Antrim ores is shipped from Larne, and other ports along the coast, to Cumberland and Wales, to be mixed with richer ores in smelting. The specimens of rock salt were from Duncrue salt mine, about eight miles from Belfast. This mine, which is in the New Red Sandstone, reaches a depth of 112 fathoms. The deposit is more than 150 feet thick, and was discovered in 1850, in

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boring for coal. It is wrought in steps or galleries, large square pillars being left to support the roof, and on the whole has much the appearance of the Giffnock sandstone quarries, which most of the members have visited.

Mr MAYER, at the request of the Chairman, gave some information regarding the valuable ironstone deposits in County Down.

Mr DANIEL WILSON laid on the table some interesting specimens of quartz and slate rocks from Easdale and North Wales.

Mr JOHN BURNS exhibited some beautiful examples of rock-crystals from the granite quarries of Aberdeenshire.

Mr JOHN YOUNG, F.G.S., Vice-President, made some instructive remarks on the specimens which had been brought forward, and moved the thanks of the meeting to the exhibitors, which were cordially agreed to.

12TH NOVEMBER, 1874.

Mr E. A. WÜNSCH, *Vice-President*, in the Chair.

Mr David Sandeman, Mr John Farquhar, and Mr J. M. Ross, were elected Life Members; and Mr William Robertson, C.E., and Mr Robert Marshall, Resident Members of the Society.

Mr THOMAS NAISMITH exhibited a beautiful collection of fossil ferns from Mount Vernon and Carnbroe; also, well-preserved heads of *Woodicrinus* from the Carboniferous limestone of Richmond, Yorkshire.

Mr PETER DEWAR submitted an interesting suite of Carboniferous fossils from the limestone quarries at Orchard.

The CHAIRMAN gave a preliminary notice of an interesting discovery which he had recently made in Arran, during a joint exploration of the northern part of the island with Mr James Thomson, F.G.S. As was well known to the members, the age and geological position of those large masses of red sandstone adjoining the Carboniferous series of Arran has hitherto been doubtful—some geologists viewing them as part of the Carboniferous series, others thinking they might be of later date. In the course of their examination of these sandstones, they came upon a bed of conglomerate of highly glacial aspect, enclosing angular fragments of various volcanic, schistose, and limestone rocks; and in the latter Mr Thomson's keen eye detected the familiar aspect of Carboniferous shells and corals. Having once obtained this clue, it was not difficult to find other beds at higher and lower levels, containing similar traces of Carboniferous fossils, thus fixing these massive beds of sandstone as undoubtedly of Lower Permian age. The character of the rocks at the north end of the island being thus determined, there was little doubt that the still more massive sandstone, south of the great anticlinal at Glen Sannox, would be found to be of the same age, and this point was hopefully reserved for future investigation.

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CARBONIFEROUS POLYZOA.

Mr J. Young, F.G.S., Vice-President, read a joint paper by himself and Mr David Robertson, F.G.S., entitled, "Note on the Polyzoa of the Hairmyres Limestone Shale, East Kilbride." (See p. 173.) The authors exhibited a large suite of finely-preserved and beautifully-mounted specimens of the various organisms, which were examined with much interest by the members.

The next paper was by Mr Dugald Bell on "Glacial Mounds near Balquhidder, Perthshire." (For an abstract see p. 234.)

Thanks were voted to the authors of papers and exhibitors of specimens.

10th December, 1874.

Mr John Young, F.G.S., *Vice-President*, in the Chair.

Mr James Dairon and Mr Thomas Lamb were elected Life Members; and Messrs Joseph Taylor, John Belch, John Munro, John Wilson, Donald M'Gregor, James Allan, Alexander Hill, John Thompson, Richard Sandeman, John Stevenson, James Galbraith, LL.B., and James White, Resident Members of the Society.

Mr James Neilson, jun., exhibited a selection of fossils from the Irish and Scottish limestone beds, and read a paper "On the Armagh Limestones, and their equivalents in Scotch strata." After describing the general succession of Carboniferous strata in Ireland as consisting of the following divisions, in descending order—coal measures, millstone grit, upper, middle, and lower limestones, and Carboniferous slates, resting on the Old Red Sandstone—he remarked that the upper portion of the Old Red Sandstone might probably be added to the Carboniferous system, as it contained many remains of plants, and seemed to be the equivalent of the Ballagan series in the West of Scotland. The "Carboniferous slates" include the Kildress sandstone, which consists of red and yellow sandstone, and beds of limestone containing *Athyris*, *Spirifera*, *Rhynchonella*, &c. The three divisions of the limestone—lower, middle, and upper—present a development very different from that found in Scotland. Here we have great beds of shale, with comparatively thin beds of limestone; there, on the contrary, the limestone is of great thickness, with thin beds of shale. Some sections show many hundred feet of limestone, simply parted by thin bands of shale here and there. These limestones cover the greater part of the South and West of Ireland, "choking out," as it were, the upper coal measures, which only exist in small detached patches. The Armagh limestones belong to the lower division, and correspond with those found in Scotland at Campsie, Kilbride, Carluke, Lesmahagow, Muirkirk, and Beith, as well as at several points on the East Coast. So far as regards the fossils, the limestones at Beith present the most striking likeness to

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those of Armagh. The latter have long been famous for their fish remains. These were collected in the last generation by Admiral Jones, and at the present time the Earl of Enniskillen has obtained a large and splendid suite of fossils from these beds. These fish remains were first described by Agassiz; they are also figured in "Portlock's Geological Report of Londonderry," and in "Sedgwick and M'Coy's Palæozoic Fossils." With the assistance of these works Mr Neilson had identified 21 species, 14 of which are found in Scotland. He concluded by pointing out the characteristics of several of the species, and calling attention to their state of preservation, which, in many cases, was equal to that of the best Scottish specimens.

Mr JAMES DAIRON read a paper "On the Graptolites of the Upper Llandeilo Rocks of the South of Scotland," (and which, incorporated with a subsequent paper, will be found at p. 176.) Mr Dairon's paper was illustrated by drawings, and by a fine collection of specimens.

Several members having spoken, the CHAIRMAN said that he was glad to see members of the Society taking up special branches of Palæontology, and working them out so carefully as the authors of the papers which had been read. He considered it the true way to prosecute the study of the science, and one that would contribute much to the interest of their meetings as a Society. He then noticed some of the points which had been alluded to by Mr Neilson and Mr Dairon, and concluded by conveying the thanks of the meeting to these gentlemen for their communications, and for the specimens they had brought forward.

14TH JANUARY, 1875.

Mr JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Messrs David Fulton, John Mayer, William Rodgers, C.E., and Peter Wright, were elected Resident Members.

Mr THOMAS NAISMITH exhibited a beautiful suite of fossils from various formations, from the Lower Silurian to the Lias and Oolite inclusive. The variety and beauty of the specimens were much admired.

Mr JOSEPH SOMERVILLE brought forward an interesting collection of shells from the Carboniferous shales of the Glasgow district.

The CHAIRMAN made some remarks illustrative of the specimens, and returned the thanks of the meeting to the exhibitors.

Mr DUGALD BELL read a paper "On the Geology of Switzerland," an abstract of which will be found at p. 236.

The CHAIRMAN suggested that some points in the paper ought to be taken up for discussion on a future evening, and in the meantime conveyed the thanks of the meeting to Mr Bell for his interesting and instructive communication.

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28TH JANUARY, 1875.

SPECIAL MEETING.

Mr E. A. WÜNSCH, *Vice-President*, in the Chair.

A letter was read from Dr JAMES BRYCE, F.G.S., expressing regret at his inability to be present, and requesting the Society's acceptance of some geological diagrams and specimens which he forwarded.

The donation included Geological maps of the Crimea, of the Lake district of England, and of the North of Ireland, also a valuable suite of fossils illustrative of the Geology of Skye and other parts of the North-west of Scotland.

The CHAIRMAN moved a cordial vote of thanks to Dr Bryce for his friendly and generous gift, and the Secretary was instructed to convey the same in due form.

Mr JAMES DAIRON made some remarks upon Mr Bell's paper on Switzerland, expressing doubts as to the erosive action of glaciers, and stating that during a visit he had paid to that country, he had not seen anything like boulder-clay.

Mr JOHN YOUNG, F.G.S., Vice-President, stated that he conceived the true theory of the formation of boulder-clay to be, viz., that it was submarine, or at least, formed under the seaward extension of the ice-sheet. He opposed the views of Mr James Geikie and others, and thought that if any boulder-clay existed in Switzerland, it must have been deposited by the glacier ice in lakes.

The CHAIRMAN made some observations, and Mr Bell then briefly replied.

11TH FEBRUARY, 1875.

ANNUAL BUSINESS MEETING.

The Annual Business Meeting for the election of office-bearers was held in the Natural Philosophy Class-Room, University, Mr E. A. WÜNSCH, *Vice-President*, in the chair.

Messrs. O. Niven and Alexander Leitch were elected Resident Members.

The Society then proceeded to the election of Vice-Presidents for the ensuing year, the President's term of office having still a year to run. The result was therefore as follows:—

President—Sir WILLIAM THOMSON, LL.D., F.R.S., &c., Professor of Natural Philosophy, University of Glasgow.

Vice-Presidents—EDWARD A. WÜNSCH, JOHN YOUNG, F.G.S., JAMES THOMSON, F.G.S.

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The hour for the delivery of the President's address having arrived, the election of the other Office-bearers was postponed until next meeting.

Sir WILLIAM THOMSON, the President, then delivered a very able and comprehensive address on "Underground Temperature."

Mr WÜNSCH proposed a cordial vote of thanks to Sir William Thomson for his interesting and suggestive remarks, which was carried by acclamation.

11TH MARCH, 1875.

ADJOURNED ANNUAL BUSINESS MEETING.

Mr JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

The results of the election of the remaining Office-bearers were as follows:—

Corresponding Secretary—DUGALD BELL.
Joint Secretary—JOHN BURNS.
Treasurer—JOHN WIGHT, C.A.
Librarian—RICHARD NEILSON.

Other Members of Council—ARCHIBALD ROBERTSON, JOSEPH SOMERVILLE, DAVID SANDEMAN, JOHN ORR, DANIEL WILSON, HUGH M'PHAIL, JAMES DAIRON, ARTHUR PRATT, THOMAS NAISMITH, THOMAS M. BARR, D. C. GLEN, DAVID ROBERTSON, F.G.S.

The Hon. The Lord Provost (James Bain), Messrs Paul Rottenburg, and Robert Raphael were elected Life Members.

The following papers were then read:—(1) "On a Tract of Vertical Trees in Carboniferous strata." (See p. 184.) (2) "On River Debris found in Sandstone," by Dr WILLIAM GROSSART of Salsburgh, corresponding member. (See p. 188.)

An interesting discussion followed, in which Mr James Neilson, jun., Mr James Thomson, F.G.S., Mr E. A. Wünsch, Mr Thomas Barr, and the Chairman took part. The Secretary was instructed to convey the thanks of the Society to the author for his valuable communications.

Mr THOMAS NAISMITH exhibited a fine series of Arctic shells from the well-known clay-beds at Dalmuir. The shells were in good preservation, and were much admired.

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25TH MARCH, 1875.

Mr JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

SPECIAL MEETING.

Mr D. CAMERON moved, and Mr A. ROBERTSON seconded, the adoption of the following resolutions, which were unanimously agreed to:—

(1) "That it is the opinion of the members, with all respect to the present Vice-Presidents, that more frequent changes in those elected to that office than have of late been the case would be advantageous to the interests of the Society, and that the Council be requested to frame such alteration or additions to the Rules as they may deem expedient, and submit the same to the members for approval."

(2) "That the members deprecate the haste with which it has of late been necessary to conduct the election of Office-bearers, and recommend that in future a Special Meeting of the Society should be called for that purpose."

In accordance with these Resolutions, it was remitted to the Council to consider and bring forward such amendments in the laws of the Society as might seem to be desirable.

15TH APRIL, 1875.

Mr JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Messrs Alexander Whitelaw, M.P., John Tennant, Thomas Clavering, John Dron, W. Smith Yuille, Bailie William Collins, were elected Life Members; and Messrs John Young and Robert Murdoch, Resident Members.

The CORRESPONDING SECRETARY laid upon the table copies of the amended Constitution and Laws of the Society as approved of by the Council, and gave notice that their adoption would be moved at next meeting.

Mr JAMES THOMSON, F.G.S., Vice-President, read a paper "On the Geology of the River Liddell, Dumfriesshire," in which he described some of the fine sections exposed along the banks, which showed wonderful contortions with great faults and "downthrows" of strata. He also referred to the identity of the fossils found in a band of impure limestone in that district with those found in many parts of the Ayrshire and Lanarkshire coalfields. Mr Thomson illustrated his remarks by a sketch representing a section of the country for a distance of about 20 miles.

Mr WÜNSCH and Mr BELL having made a few remarks, to which the author briefly replied,

Mr THOMSON then submitted some notes on new species of Carboniferous Corals, giving particulars of his recent investigations into that group. He exhibited a number of photographs and of plates beautifully executed by

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a new process, and which showed the varieties of Coral texture, which had been recently brought to light.

Mr DAVID ROBERTSON, F.G.S., brought forward an interesting and well arranged collection of shells from the Raised Beach at Cumbrae. A paper by Mr Robertson on the Post-tertiary deposits of the island was unavoidably postponed.

Mr WÜNSCH, Vice-President, exhibited a fine suite of minerals and fossils from Japan, and the thanks of the meeting were awarded to him, as well as to Messrs Thomson and Robertson.

29TH APRIL, 1875.

Mr JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Messrs John Whyte, Alexander M'Ouat, James Coutts, Archibald Fawcett, and Rev. R. M. Gibson, were elected Resident Members.

After consideration of the amended Laws of the Society, tabled at last meeting, it was moved by Mr KIRSOP, seconded by Mr D. CAMERON, and agreed, that they be passed and adopted as the Laws of the Society.

13TH MAY, 1875.

Mr E. A. WÜNSCH, *Vice-President*, in the Chair.

Messrs David Murray and John Belch were elected Life Members.

An interesting paper "On a Raised Beach at Cumbrae," was then read by Mr DAVID ROBERTSON, F.L.S., F.G.S. (See p. 192.)

At the close of the paper, which was illustrated by a fine series of shells, etc., some remarks were made by the CHAIRMAN, Messrs JOHN YOUNG, F.G.S., and JAMES THOMSON, F.G.S.

Mr THOMSON then read a paper, entitled, "On the Geology of the Island of Islay," (see p. 200), illustrating it with a large series of rock specimens, and by maps and sections.

Mr JAMES NEILSON, jun., read a paper, "Notes on the Geology of the Railway Cuttings between Bellgrove and Springburn," (see p. 222), and showed a number of specimens of fossils from the sections exposed during the work.

Messrs JOHN YOUNG, F.G.S., and JAMES ARMSTRONG read a paper "On the Fossils of the Orchard Limestone series," (see p. 250,) in continuation of previous papers by the same authors. Mr Young exhibited a beautiful series of the Foraminifera and other minute fossils found at Orchard, while Mr Armstrong showed an equally fine series of Brachiopoda, and the larger organisms.

The CHAIRMAN made some remarks, congratulating the members upon the happy conclusion of the Session.

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PROCEEDINGS FOR THE SESSION 1875–76.

Ordinary Meeting.

28th October, 1875.

Mr E. A. Wünsch, *Vice-President*, in the Chair.

Mr William Murdoch was elected an Ordinary Member of the Society. Messrs Hogg and Baxter were appointed Auditors of the Treasurer's accounts.

Mr Arthur Pratt exhibited a specimen of Albertite from the mines, Albert County, New Brunswick, Nova Scotia, which was supplemented by other specimens shown by Mr D. C. Glen, and by Mr John Young, F.G.S. The latter, in making some explanatory remarks, said—Albertite is a bituminous mineral, as black and as brilliant as jet, with a fine conchoidal fracture. It is found filling veins which traverse the strata in a nearly vertical position, and varying from 1 to 16 inches in thickness. It is closely related to asphalt, melting in the flame of a candle and dissolving in naphtha and other solvents. On an average it yields 110 gallons of crude oil per ton, of which 70 per cent. may be made into a brilliant lamp oil. Albertite has been discovered in Sutherlandshire in rocks near the junction of the Old Red Sandstone with the metamorphic schists, and is said to be of quite as fine a quality as that from the New Brunswick mines. Unfortunately it has only been met with in veins rarely exceeding from one to two inches in thickness, which renders it commercially useless.

Mr Robert Craig, Langside, Beith, Corresponding Member, then read a paper entitled "Notes upon a Shell bed at the West-end of Arkleston Tunnel, near Paisley." In the course of it Mr Craig said—This shell-bed lies in a hollow in the boulder-clay, immediately at the west end of the tunnel, and rests against the rock on the north side of the railway, but not so on the south side. It has on the north side a depth of 14 feet at the place where the foundation for a bridge has been dug out, being seven feet below the line of rails, and extends along the north bank of the cutting, rather irregular in thickness, for a distance of 72 yards, when it finally thins off. It has been exposed in breadth about 30 yards, its outcrop being to the south of the railway, with a trend running north-west. On this side its thickness is never above two feet, deepening as it dips to the north, or rather north-east, which is the true dip. Shells are found throughout all parts of the bed, but are more abundant in thin bands of muddy sand which are intercalated in it, and in the bottom just overlying

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the boulder-clay, than they are amongst the clay itself. The clay, of which the bed is principally composed, is very similar to the brick-clays of the locality—a little more muddy, perhaps, where it assumes its greatest depth. Near the outcrop it is finely laminated, but here shells are not so plentiful as where the depth is greater, and where the lamination is not so well marked. How far it extends northwards we have at present no means of ascertaining, but there is a probability that it has a considerable area in this direction. As already mentioned, it lies upon a bed of boulder-clay, the dimensions of which we have no means of knowing, but so far as cut into, it is a very soft muddy clay, full of small stones, with very few large boulders. It abuts against the rock through which the tunnel passes, but does not rise to the level of the rails on the north side, while reaching a few feet above them on the south side of the railway. For about 50 yards westwards from the tunnel its height above the rails runs from 3 to 5 feet, but at that distance it rather suddenly rises to 18½ feet above them, and so continues for a hundred yards, when it again decreases, and finally dips below the line at a distance of 300 yards west of the tunnel. The north bank follows the rise and fall of the south bank, but owing to the boss of boulder-clay dipping to the north, it is thinner by 6 feet on this side. It will thus be perceived that a hollow exists between the rock and the place where the boulder-clay reaches its greatest height, and in this hollow has been preserved the shell-bearing laminated clay. Overlying the shell-bed, south of the railway and abutting on the rock, is a bed of very fine white sand, free from stones, and about 10 feet thick. Upon this rests a bed of coarse gravel, 9 feet 9 inches in thickness. Neither of these beds contain shells, but both are finely laminated. They thin off towards the north and west, and are cut out about 50 yards west of the tunnel, where the boulder-clay rises to 18 feet above the rails. Portions of them again appear when the boulder-clay begins to dip, and they continue at a reduced depth about 400 yards west of the tunnel, where they sink below the level of the railway. On this west side of the boss of boulder-clay, patches of the laminated shell-clay are found, but containing no shells, as they have most probably decayed from the action of air and water percolating through the overlying coarse gravelly soil, which is at this place not more than two feet thick. As, on the north side, near the tunnel, the shell-bed is covered by only one foot seven inches of earthy sand, it is evident that the overlying beds, at this point, have been removed by human agency, and it is probable that this was done when the railway was originally made, just as the sand-bed on the opposite side is now being removed for building purposes.

Mr JOHN YOUNG, F.G.S., gave some very interesting additional details regarding the great shell-bed, of which this forms a portion, and which fringes the estuary of the Clyde on both sides and at various levels. He mentioned, incidentally, that the barnacle-covered boulders, lately brought up in the dock-building operations at Stobcross, were encrusted with a *Balanus*—still living in our seas—*B. balanoides*.

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Mr JAMES THOMSON, F.G.S., said, in speaking of the importance of Mr Craig's paper, that the trap bed about to be cut through at Arkleston was perhaps one of the most interesting in Scottish geology, and that members should pay particular attention to the forthcoming operations at this place.

A paper "On a Shell Deposit near Largs," was then read by Mr DAVID ROBERTSON, F.G.S. The last excursion for the season, in the summer of this year, was to Largs, under the guidance of Mr Wünsch, the particular object of interest being a shell deposit which he had discovered between tide marks, and about a quarter of a mile west of the town. Whether this deposit belongs to the old Raised Beach or to lower lying silts, or whether it is a comparatively recent deposit, might be difficult to decide satisfactorily, as the shells of all these three are found living in the neighbouring seas, while both Ostracoda and Foraminifera, being more cosmopolitan than the Mollusca, and of more variable distribution, afford little chronological help. The deposit consists of muddy sand and shell debris, about a foot in thickness, resting on red till and quite near the surface, being covered by only a few inches of sand and washed over by every tide. One remarkable feature is the great abundance of the mollusc *Pecten maximus*. A considerable number of specimens were dug up by the party during the short time allowed by the tide, but nothing compared to the quantity collected by Mr Wünsch, who, with four assistants, dug up twenty dozen during one ebb tide. Most of these shells had the valves together, and were lying with the concave side down as in life, few of them being broken or in any way water-worn. One valve of *P. maximus* was found, having adherent to it a large specimen of *Balanus porcatus*—a fact of considerable interest connected with this deposit, and the first occurrence of the connection in the author's experience. This *Balanus* is of frequent occurrence on *Pecten Islandicus*, a mollusc not now living in our seas, but which survives in every part of the Arctic Ocean at depths, according to Jeffreys, ranging from 15 to 150 fathoms. The frequent presence of large *Balani* on *Pecten Islandicus*, and their absence on *P. maximus*, has been supposed to mark a distinctive character between the Pectens of the glacial clays and those of the raised beaches, but may be accounted for by the fact that *Balanus porcatus* appears to have been greatly more plentiful when *Pecten Islandicus* lived in our seas than during the formation of the old Raised Beaches, for we seldom meet with *Balani* in these latter, nor are they indeed common in the Firth of Clyde. As stated above, all the Mollusca of this deposit still live in neighbouring seas. There is, however, one exception, as in this bed there was met with a specimen of *Astarte borealis*, which is a common shell in glacial deposits, but has for the most southern known limit of its recent habitat, on the authority of Jeffreys, Kiel Bay in the Baltic. Belonging to a group quite different from that in which it was found, there can be no doubt that this specimen has come from a

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glacial deposit which is known to exist at a short distance along the shore towards Fairlie, and it can therefore give no character to this bed. That the Mollusca of this deposit do not belong to an old sea-beach may be reasonably inferred from the fact that many of them have their valves together and are lying in their natural position as they had lived, and are in no way drifted up or promiscuously huddled together as they would be in an old sea-beach. Neither can it be supposed that they belong to recent deposits, as *Pecten maximus* is far from being common in the Firth of Clyde, perhaps only one or two being met with in a day's dredging. It is never found living gregariously between tide marks, nor even to be seen at all between high and low water. Forbes says it has a range of from 3 to 40 fathoms, but occurs most abundantly on the banks of *P. opercularis*. Jeffreys says, that it is often gregarious on banks, in 7 to 8 fathoms water, but there nowhere appears mention that it has been found within the littoral belt. Such facts appear to lead unavoidably to the conclusion that these Mollusca lived and died where they now lie, and at a time when the sea stood higher than at present; and that although they never formed any part of the old beach, it is quite possible that they were contemporaneous with it, and were inhabiting the deeper reaches of the sea when the beaches were forming at a higher level. This is so far borne out by the fact that *P. maximus* is not unusual in the old sea-beaches round the neighbouring seas. Doubtless this bed is a detached patch of one overlying the Post-tertiary clays containing Arctic shells, and which lies between tide marks a little to the east of Fairlie. There is another of the same character at Colintraive. When deep-water shells occur in quantities within or above tide-marks, they may be referred with more certainty to their proper position than shells met with in positions corresponding to their natural habitats. In many of our silts, some of them of great depth, where all the organisms from bottom to top belong to surrounding seas, and which we may reasonably suppose were accumulated at very different rates of deposition, it is very difficult to draw any line to mark the relative time between the various layers, beyond what is afforded by superposition. The whole may be comparatively recent, or one portion may be so while another may have preceded the last elevation of the land, thus showing that there is no real break in the fauna between the period of glacial clays containing Arctic shells and that of the present time, which we may look upon as a geological epoch in this country not yet complete.

Mr Wünsch said that he had passed about 1500 specimens of *P. maximus* from this deposit through his hands, having found them economically useful for the purposes of oyster culture, in which he was at present making a series of experiments on a considerable scale, and that therefore the conclusions as to the rarity of the occurrence of *Balanus porcatus* in connection with this shell were not hastily arrived at.

Mr John Young, F.G.S., said that this mollusc was more of a southern

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form, which was evidently introduced after the disappearance of *Pecten Islandicus*, *Balanus porcatus*, and many other shells from our neighbouring seas.

Mr JAMES THOMSON, F.G.S., also made some remarks on Mr Robertson's paper, and more particularly mentioned the fact that *Pecten maximus* was both gregarious and migratory in its habits, so that while met with in comparative numbers at one time in a particular locality, it might not again be found at or near the same place.

Mr WÜNSCH read a paper on "Columnar Sandstone in Arran," in the course of which he said—The patch of columnar sandstone now to be described occurs in the New Red Sandstone on the shore, about half-a-mile south of Lamlash. The portion distinctly rendered columnar is about three feet wide and ten to fifteen feet in length; but further portions may be concealed by the shore gravel, or may extend beneath the sea. The immediate cause of the rock having assumed this form is at once apparent, from its being almost entirely enclosed within two massive trap dykes, one of them ending in a remarkably sharp and well-defined wedge, as shown on the ground plan; the other also apparently ending in a wedge in the opposite direction, although, owing to the surface being covered with debris, its termination could not clearly be traced. The trap dykes are perpendicular, and the columns of the sandstone which are irregularly pentagonal, as seen in the specimen on the table, lie of course at right angles to the sides of the dykes. The sandstone is of a white colour, highly quartzose, and much indurated. The beds are nearly horizontal, and in the immediate neighbourhood of the columns the colour of the sandstone is also white, although at no great distance it merges into the buff and red shades, characteristic of the great mass of sandstones in this locality.

Mr JOHN YOUNG, F.G.S., in some observations on the above paper, said that sandstones used for bottoming iron furnaces assumed, from the long-continued heat, a distinctly columnar form, often at right angles to the old lines of stratification, which were often quite obliterated, thus showing to demonstration that heat and pressure were the cause of columnar structure in such cases as Mr Wünsch's interesting example. In the case of columnar sandstone from Bute, brought before the Society by Mr Glen two years ago, there was, however, no apparent contact with trap dykes.

Mr D. CORSE GLEN, C.E., made some remarks on a quartziferous porphyritic felstone, forming one of the beds of trap in the hills of Garrochhead, Bute. The rock is of a light grey colour, and encloses numerous crystals of a glassy white orthoclase felspar, and small crystals of grey quartz. A similar felstone porphyry is found in Arran, and probably belongs to the same period of eruption. Mr Glen stated that recently this porphyry at the Garrochhead had been quarried by the Marquis of Bute for the purpose of obtaining pillars and other ornamental work for the alterations at Mountstuart House. For this purpose it only suits some-

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what indifferently, as the rock is much fissured, large blocks not being easily obtainable. Neither does the stone take a very high polish, as it contains numerous small porous cavities, while the felspar in the crystals is partly decomposed into a chalky white condition. This light grey porphyry is, however, of considerable geological interest, as it forms a well-marked and characteristic variety, which seems to be restricted in the West of Scotland to Bute and Arran, while it occurs as one of the interbedded igneous rocks amongst the ordinary varieties of trap. A specimen of a recent trachytic porphyritic lava from Vesuvius was exhibited beside the Bute porphyry for comparison. The resemblance in colour of the felspar crystals, and that of the matrix in the two rocks was very striking, the only difference in the Bute and Arran specimens from that from Vesuvius being the free crystals of quartz, which, however, may have been developed in the matrix by a subsequent metamorphism of the rock, free crystals of quartz being rare in any other of the trap rocks. Mr Glen also exhibited two polished specimens of porphyry from Lochfyne-side, much used some years ago for causewaying the streets in Glasgow, but now superseded by granite. One was of a light grey, the crystals of white felspar being distinct, and taking on a good polish. The other had a reddish tinge, and a finer grain than the grey variety, but also polishing well.

18th November, 1875.

Annual General Meeting.

Mr E. A. Wünsch, *Vice-President*, in the Chair.

Messrs Robert Kerr, H. Riddell, Thomas Brown, James Smith, A. C. Burns, John Morris, and J. H. Bennet, were elected Resident Members.

Mr Murdoch, Secretary, read the Annual Report of the Council as follows:—

The number of Resident Members on the roll is 156 as compared with 158 in the past year. Of these 28 are new members, showing very plainly that but for the enrolment of new names, the number of members would more or less rapidly diminish. The Council would therefore urge on every member the advantage and indeed necessity of bringing in new members.

There are also from 15 to 20 members in arrear of subscriptions, some of which may still be recovered.

An additional reason exists this year why the membership should be largely increased, viz., that the financial affairs of the Society are not at all satisfactory, or, in other words, that the expenditure has exceeded its income.

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LIFE MEMBERS.—A feature of some importance during last year, has been the great accession to the list of Life Members—16; which makes the total number on the list amount to 20. The Council hope that considerable as this list is, it may be largely increased during the coming year.

ORDINARY MEETINGS.—These were well attended. Various papers were read by members, some of exceeding local interest, while others were of wider scope. Notable amongst the latter was the presidential address by Sir William Thomson upon Underground Temperature, a subject of general importance, and which was treated in a way worthy of Sir William's great reputation.

As remarked in last year's Report, the Council would be glad to see, more frequently than heretofore, papers, however short, from some of the younger members, it being of the greatest importance that additions should continually be made to the workers in the Society.

As formerly, several papers were contributed by Corresponding Members, to whom consequently the thanks of the Society are due.

The SPECIMENS exhibited were in many instances of great beauty and value, those shown in illustration of papers adding much to the interest of the various subjects.

EXCURSIONS during Spring and Summer were as follows:—

		CONDUCTOR.
April 24	—Gleniffer Braes, . . .	Mr M'PHAIL.
May 1	—Linn Spout, Dalry, . .	Mr JAMES THOMSON, F.G.S.
„ 8	—High Blantyre, . . .	Mr D. CORSE GLEN, C.E.
„ 2	—(Queen's Birth-day) Castle Campbell, Dollar.	
„ 29	—Corrieburn, . . .	Mr JOHN YOUNG, F.G.S.
June 12	—Largs, ...	Mr E. A. WÜNSCH.

These were well, and in some cases largely attended, and were undoubtedly of much benefit to the younger members, who took the field under such practical leaders as the gentlemen who conducted the various parties, and to whom therefore the Council feel much indebted.

The MUSEUM was enriched during the Session by several gifts of specimens, more particularly by that of Dr JAMES BRYCE, F.G.S., who presented to the Society a large series of rock specimens illustrative of the Geology of Skye and other districts in the north-west of Scotland.

The LIBRARY, as in previous years, has been much made use of by members. The want of additional accommodation is still severely felt, and it is quite requisite that at least one other book-case should be provided without delay.

The exchange of publications with kindred Societies is still kept up,

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and the books received in this way from time to time form by no means the least valuable portion of the Society's Library.

PUBLICATIONS.—During the past Session Part I. of Vol. V. of the Transactions was printed and issued to members. It contained a number of valuable papers read between 30th October, 1873, and 16th April, 1874. No steps have yet been taken towards printing the 2nd Part of the 5th Volume, but the Council hope soon to be in a position to undertake its issue. The stock in hand of back Parts is considerable, and it is therefore hoped that members who may still have imperfect sets will complete them, and so help to release some of the locked up funds.

THE CORRESPONDING SECRETARY.—Owing to his business engagements calling him to India, your active and energetic Secretary, Mr DUGALD BELL, resigned his post about the end of the Session, and though at first intended to be only temporary, he has since written to say that his resignation must be considered as final.

Mr JOHN WIGHT, C.A., read the Financial Statement. (See Abstract on page 337.)

The election of Office-Bearers was then proceeded with, showing the following result:—

President—Sir WILLIAM THOMSON, LL.D., F.R.S., &c., Professor of Natural Philosophy, University of Glasgow.

Vice-Presidents—Messrs JOHN YOUNG, F.G.S., E. A. WÜNSCH, and D. C. GLEN, C.E.

Secretary—J. B. MURDOCH, Hamilton Place, Langside.

Joint-Secretary—JOHN BURNS, 103 Main Street, Anderston.

Treasurer—JOHN WIGHT, 150 Hope Street.

Librarian—RICHARD NEILSON, 110 High John Street.

Members of Council—DAVID ROBERTSON, F.G.S.; DAVID SANDEMAN, ARCHIBALD ROBERTSON, HUGH M'PHAIL, JAMES DAIRON, DANIEL WILSON, THOMAS M. BARR, THOMAS NAISMITH, JOSEPH SOMERVILLE, ROBERT MASON, ARTHUR PRATT, JAMES NEILSON, jun.

9TH DECEMBER, 1875.

Mr JOHN YOUNG, F.G.S., in the Chair.

Messrs James Somerville, E. D. Dunlop, James Spence, D. M. Nelson, John M'Gilchrist, James Stewart, R. M'Kay, D. Pearson, and Dr M'Birnie, were elected Resident Members.

Mr JAMES THOMSON, F.G.S., read a paper "Upon a New Species of Megalichthys, one of the Ganoid Fishes." Mr Thomson stated that while making microscopic sections of the scales and head-plates of *Megalichthys*

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Hibberti several years ago, during investigations into *M. coccolepis* and *M. rugosus*, he found one scale which differed much from all the others. In order that the points of difference might be better indicated, he gave brief descriptions of some of the characteristic features of various species of the genus, and then said—In the new species of Megalichthys, the snout or premaxilla is not divided by a median mucus groove, as in the other species. It is round in outline at the anterior extremity, terminating on the median surface in deep mucus grooves, and at the posterior articular process in a more or less pointed form. It is deeply denticulated along the posterior margin, which inosculates into the anterior face of the frontal bones, these being more or less rhomboidal in outline, while along the mucus grooves they are also deeply denticulated, but there are none of the plates on the crown of the head rhomboidal, as seen in *M. Hibberti*. The anterior faces of the parietal bones terminate more or less acuminately, and are deeply denticulated along the muscus grooves. The epiotics are somewhat rhomboidal, narrowing at their anterior extremity, and are more or less denticulated. The laniary teeth are minutely striated, the striæ being larger on the concave or inter face, and they might readily be mistaken for the teeth of *Strepsodus sauroides*. They are also longer than those of other species of Megalichthys. The serial teeth are also longer and stouter, while both laniary and serial teeth are bent inwards. The surface ornamentation of the head-plates, and that of the body scales, more closely resembles that of *M. Hibberti* than that of either of the other two species. In the structure, as observed in the microscope, there is, however, a considerable difference. The surface is minutely punctured, and between each puncture there are numerous minute ridges, showing a somewhat vermicular structure. The scales on the body are rhomboidal in outline. It will thus be seen that the only point of agreement between all the forms rests on the fact that the body scales are all rhomboidal. In the arrangement of the head-plates there is a great difference, not only in outline, but in the individual arrangement. The teeth also differ greatly; indeed, so much so, that when once seen the variations cannot readily be forgotten. But the peculiarity of the snout is of itself a sufficient warrant for pronouncing this a distinct species. Sections have not yet been made, but Mr Thomson was inclined to think that they would show a structure approximating to that of *Strepsodus*. As, however, no vomerine teeth have been found attached to the jaw, as in *Strepsodus*, it could not be referred to that genus. A thin section taken vertically from one of the scales, which is about 1-35th of an inch thick, displays microscopic characters similar to those found in the scales and plates of many ganoid fishes, and so is intimately connected with the scales of *M. Hibberti*. Immediately below the surface is an absolutely structureless layer of the transparent ganoine, about 1-1100 of an inch thick. Through this the punctures of the surface pass into a set of short vertical canals, each widening down-

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wards, and assuming an obtuse conical form. At their bases they are connected by horizontal tubes, and this system also communicates below with a close irregular network of Haversian canals, which ramify through the lower part of the section.

Mr JOHN KIRSOP then exhibited a variety of specimens from the Wealden Borings, which, in the name of Mr H. R. Robson, President of the Institution of Engineers, he begged to present to the Society. There were also shown a number of charts and sections explanatory of the borings and of the Wealden district.

Mr D. C. GLEN, F.G.S., Vice-President, then read an interesting paper, "Remarks on the Wealden Borings." (See p. 262.)

13TH JANUARY, 1876.

Mr E. A. WÜNSCH, F.G.S., in the Chair.

Mr T. D. Smellie was elected a Life Member; and Messrs David Telfer, Robert M'Connechy, and David S. Miller, Resident Members.

Mr ROBERT CRAIG, Langside, Beith, Corresponding Member, read a paper entitled, "Remarks upon the Bed of Dolerite which crosses Renfrewshire, to the east of Paisley." (See p. 270.)

Remarks upon Mr Craig's paper were made by Mr Hugh M'Phail, Mr James Thomson, F.G.S., and Mr John Young, F.G.S., the latter stating that the same Dolerite bed had been pierced, by Mr Matthew Montgomerie when he put down a bore to the west of Garnavel, at a depth of about 100 fathoms; this depth showing a continued dip to the north.

Mr YOUNG exhibited specimens of a peculiarly coloured Calcite from Waterland Quarry, Dunlop, Ayrshire, as also specimens of Arragonite and Millerite, a sulphide of nickel, the latter a very rare mineral from Dockra quarry, near Beith.

Mr Naismith exhibited various Carboniferous fossils from the limestone at Trearne, Beith.

20TH JANUARY, 1876.

PRESIDENT'S ANNUAL ADDRESS.

Sir WILLIAM THOMSON, LL.D., F.R.S., &c., in the Chair.

The address annually given to the Members was on this occasion, at the request of the President, Sir William Thomson, delivered by Mr E. A. Wünsch, F.G.S., Vice-President.

The title of Mr Wünsch's address, which was given in the Philosophical

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Society's Large Room, Corporation Buildings, Sauchiehall Street, before a large assemblage of members and others interested in the science, was "Geology in Daily Life." At its close Sir William Thomson made some suggestive remarks. A vote of thanks to Mr Wünsch for his address brought the proceedings to a close.

10TH FEBRUARY, 1876.

Mr ARCHIBALD ROBERTSON in the Chair.

Messrs James Taylor and James Stirling were elected Resident Members.

A series of specimens of copper and other ores from Australia was exhibited by Mr John Kirsop, a brief description of them being given by Mr John Mayer, F.C.S.

Mr JAMES NEILSON, jun., exhibited a series of Carboniferous fossils from the Muirkirk district, and he also remarked upon their distribution. Mr James Thomson, F.G.S., gave a brief topographical and geological description of the locality, and spoke of it as one to which the Society might make an excursion with much profit.

Mr JOHN BURNS, Joint Secretary, exhibited a series of specimens of sands and clays, principally from Stobcross and neighbourhood, and gave some interesting facts in connection with their occurrence. For a long time he had been experimenting upon the deposition of sands and clays under various conditions, and though he had not yet finished his investigations, he hoped, at no distant date, to lay the final results before the Society.

Mr THOMSON said that the collection was an extremely valuable one, and that he hoped Mr Burns would soon be able to place the results of his labours before the members.

24TH FEBRUARY, 1876.

SPECIAL MEETING.

Sir WILLIAM THOMSON, LL.D., F.R.S., &c., in the Chair.

Professor GEIKIE, F.R.S., Director of the Geological Survey of Scotland, read a paper, "Recent Researches into the History of the Deposits known as Old Red Sandstone." (For an abstract, see p. 276.)

At the close, Sir William Thomson said that Professor Geikie had undoubtedly conferred a great benefit on the Society in giving the results of his own and his assistants' labours in a field of so much importance, and moved a hearty vote of thanks, which was cordially agreed to.

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Mr Wünsch, F.G.S., expressed the great gratification it gave the Society to see the lecturer once more among them, and he hoped that at the approaching meeting of the British Association in Glasgow Professor Geikie would be present and help them to sustain the honour of the Scottish Geologists.

Mr John Young, F.G.S., also spoke to the vote of thanks, and said that he was glad to hear Professor Geikie uphold the theory of the fresh-water origin of the Old Red Sandstone.

Mr James Thomson, F.G.S., said he was pleased to hear Professor Geikie state that he had obtained evidence of a gradual but persistent passage from the marine conditions of the Old Red Sandstone into those of the Carboniferous age.

Sir William Thomson then made some remarks upon the enormous thickness of the beds, as stated by Professor Geikie, and wished to know if there had been a continuous deposition, and also what explanation could be given of the comparative paucity of life in certain of the strata.

Professor Geikie in reply, after thanking the Society for the cordial reception they had given him, said that there was great certainty as to the measurements he had submitted. In a distance of about two miles along the shore near Dunnotar, 10,000 feet of strata were exposed, being completely tilted on end. As to animal life the conditions were probably similar to those existing in the Caspian Sea of to-day, where some parts were so salt that they seemed to be entirely devoid of life, whilst other tracts were full of organisms greater or less.

9th March, 1876.

Mr John Young, F.G.S., *Vice-President*, in the Chair.

Messrs William Ramage and George A. Waghorn were elected Resident Members.

Mr D. Cameron exhibited a number of specimens of fossils from the Upper Coal measures near Glasgow, upon which he made some remarks.

Mr D. C. Glen, F.G.S., showed examples of Lignite, one from Brazil, of a pale colour and known as "Turva," another, bituminous in character, from New Zealand, and a third from Bavaria.

The Chairman exhibited specimens of Melanterite, a native sulphate of iron found in fissures of the limestone strata of the Campsie and Hurlet series, in the pits near New Kilpatrick. He also showed a specimen of Marcasite known as coxcomb or radiated iron pyrites from the same locality, and which is not often seen in its native crystalline condition.

Mr David Robertson, F.L.S., F.G.S., then read a paper entitled,

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"Notes on a Post-tertiary deposit of shell-bearing clay on the west side of the Railway Tunnel at Arkleston, near Paisley." (See p. 281.)

In illustrating his paper Mr Robertson laid on the table a beautiful series of specimens taken from the bed described.

After some remarks by the CHAIRMAN and Mr COUTTS, Mr JAMES THOMSON, F.G.S., read a paper "On the Stratified Rocks of the Garpel Water, Muirkirk, Ayrshire." (See p. 287.)

Mr JAMES NEILSON, jun., and the CHAIRMAN, also spoke upon the subject of Mr Thomson's paper, after which thanks were voted to Messrs Robertson and Thomson, also to the exhibitors of specimens.

30TH MARCH, 1876.

Mr E. A. WÜNSCH, F.G.S., *Vice-President*, in the Chair.

Mr DONALD CAMERON exhibited a specimen of magnetic granite from Aberfeldy. Mr Cameron, after noticing the historical and poetical associations of the district, said that last July he had found, in some excavations which were being made in the square of Aberfeldy, various small granite boulders in all states of preservation, from a perfectly hard and compact one to that of a mere mass of granitic sand. Finding by the use of a small pocket magnet that this decomposed granite was highly magnetic, and that the harder specimens were so in a less degree, Mr Cameron submitted specimens to Sir William Thomson, who was surprised to find them possessing such strong magnetic properties. No granite is to be found *in situ* near Aberfeldy, and Professor Geikie believed them to have come very probably from Glen Dochart and the moor of Rannoch, where enormous masses of granite of different kinds exist.

The CHAIRMAN said that they were indebted to Mr Cameron for bringing the subject forward, as it opened some very interesting questions regarding the occurrence and distribution of magnetic granite and other rocks.

Mr JOHN YOUNG, F.G.S., said that Mr Cameron's specimens were the first of the kind he had seen. He suggested that these boulders might have been drawn from the granite of the Bonaw region.

Mr D. C. GLEN, F.G.S., also made some remarks referring to the discovery of magnetic sand in Bute by Mr Archibald Gray two years ago, and which he (Mr Glen) had since detected nearly all round the island.

Mr DAVID ROBERTSON, F.L.S., F.G.S., then read a paper entitled, "Garnock Water Post-tertiary Deposit." (See p. 292.)

Mr Robertson's paper was illustrated by a large and beautifully prepared series of specimens.

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Mr JOHN YOUNG, F.G.S., exhibited the new Geological Survey Map of the Campsie district upon the 6-inch scale, and for this early copy he was indebted to Mr Jack of the Survey staff. Mr Young, whose acquaintance with this district dates back from his earliest years, then gave a short but graphic sketch of its salient features, many of which had been visited by the members of the Society in by past-years.

20TH APRIL, 1876.

Mr D. C. GLEN, F.G.S., in the Chair.

Mr JAMES DAIRON read a paper entitled, "Notes on the Silurian Rocks of Dumfriesshire, and their fossil remains." (See page 176.)

In illustration of his paper, Mr Dairon exhibited a fine collection of Graptolites and allied forms.

Mr JOHN YOUNG, F.G.S., said it was a matter of congratulation that the Society should number amongst its members at least one who had made a speciality of Graptolites To the uninitiated these organisms might seem of small consequence, but they are, on the contrary, of great interest and importance. Mr Dairon has added from the Moffat field some new forms to the list of species, and his collection is certainly not rivalled in the West of Scotland, and possibly not in Britain.

Mr JAMES THOMSON, F.G.S., and the CHAIRMAN, also made some remarks commendatory of Mr Dairon's paper, the latter mentioning a curious use of the alumina shale by the inhabitants of the Moffat district—that of steeping it in water and using the liquid as a wash to cure sore mouths.

Mr DAVID ROBERTSON, F.L.S., F.G.S., then read the following note "Upon the discovery of marine forms at a higher level than previously known in the neighbourhood of Glasgow :"—These Ostracoda were found in laminated clay taken from the sewer, cut in the early part of this season, in Campbell Street where it enters Sauchiehall Street. I have occasionally obtained Foraminifera, generally *Polystomella striato-punctata*, a genus common both to marine and brackish-water conditions, and which, therefore, indicates a marine or submarine origin of the deposit; but in this case the presence of Ostracoda, and, chiefly a marine species, *Xestoleberis depressa*, which inhabits the deeper water below the tidal belt commonly ranging from 2 to 60 fathoms, gives a decided marine character to the bed in which they are found. The most important facts are that this deposit is 102 feet above the present sea level, and that the elevation is the greatest, so far as I know, at which marine fossils have been found in the neighbourhood of Glasgow; but as similar organisms have been got

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more than 400 feet above sea-level at Chapelhall, near Airdrie, there is no reason to doubt that such exist at as great a height, or even higher, in our own district, were they only looked for when opportunities occur. One reason why the discovery of similar remains is not more frequent, is that objects which may be seen at a cursory inspection are looked for, and when they are not found the deposit is pronounced barren, though all the time it may abundantly contain such minute crustaceans as those I have noticed above.

Mr JOHN YOUNG then gave a descriptive notice of the district to which the Society proposed to take the annual picnic excursion on the Queen's Birth-day, viz.: the Touch Hills and Carse of Stirling. Mr Young spoke of its memorable historic associations, and also of its interesting geological features, and hoped that Queen's weather would be the good fortune of the gathering on the 25th of May.

Mr JAMES NEILSON, jun., exhibited a specimen of Graphite artificially produced in the process of iron-smelting, on which Mr Mayer, F.C.S., and Mr Glen, F.G.S., also made some remarks.

Mr JAMES THOMSON, F.G.S., stated that when recently at Tarbert in Harris, he was struck with the appearance of certain rocks which were interstratified with a dark grey metamorphosed shale. In the former he found some structure-like markings which caused him to examine the mass more carefully. Closer examination showed that in several of the specimens appeared elongated cellular-like chambers with minute transverse bars, suggesting that such might be of organic origin. The question arose then, Do they belong to *Eozoon Canadense*, discovered by Sir William Logan in the Laurentian rocks of Canada? As the rocks of this part of the West Highlands belong also to the Laurentian group, it is all the more probable that similar organic remains may be found in them.

Not being acquainted with the structural details of *Eozoon Canadense*, Mr Thomson felt the desirability of submitting his specimens to authorities on that interesting but obscure organism. He therefore sent a specimen of the rock to a lapidary, who prepared thin slices of the most promising portions, which were then submitted to Prof. H. A. Nicholson of St Andrews, who had, he knew, opportunities of studying the original specimens of *Eozoon Canadense* in America, and he at once pronounced the Harris structure to be of organic origin. Mr Thomson also submitted the sections to Mr R. Etheridge, jun., palæontologist to the Geological Survey of Scotland, who also pronounced them to be organic, stating indeed, that if not so, he never had seen organic structure in a fossilized form. He also requested that Mr Thomson would allow him to show them to Prof. Geikie, which he did. The result of all the examinations by these gentlemen being that each pronounced the structure to be of organic origin, it was suggested that specimens should be sent to Prof. Carpenter, which Mr Thomson accordingly had done, and was now waiting his reply.

Meanwhile, there seemed to Mr Thomson to be no doubt as to the organic nature of the specimens, and from the assurance of such competent

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authorities, he felt persuaded that at last had been discovered a clue which would help to trace the life history of that great but still obscure period. He had no doubt that further investigation would yield specimens from other localities, and that the metamorphic rocks of the West Highlands would be invested with an interest they had not hitherto possessed. It seemed to him very improbable that such an extensive body of stratified rocks should be destitute of all traces of organic life. And although highly metamorphosed, through which, in all probability, many of the traces of organic life must have been obliterated, there was still hope that further evidence of the life history of the period would yet be obtained. At present he left the decision in the hands of Prof. Carpenter, well knowing that there was no one more competent to decide the question.

Mr E. A. Wünsch in a few words congratulated Mr Thomson on the important discovery which he had made.

Mr John Young stated that he was sorry that he could not agree with Mr Thomson in regarding the specimens exhibited as of organic origin. On a former occasion he had the privilege of examining specimens from the same locality, which he at once pronounced to be graphic granite, but which at the time Mr Thomson was inclined to think were of organic origin. These Mr Thomson had since admitted to be graphic granite. He, Mr Young, had looked carefully at the other specimens and sections exhibited at this meeting, and he could not see wherein they differed from the former, except in colour. In the former specimens, the grey quartz was crystallized along with a pink orthoclase felspar; in these the felspar and quartz are both of a greyish colour, and the two minerals are seen to be arranged in the rock exactly as in graphic granite. The organic structure which Mr Thomson thought he saw in the felspathic layers of the rock, he (Mr Young) believed to be the mineral cleavage of the felspar crystals. He could hardly think that any stratified rock of *organic* origin could ever be changed by any process of metamorphism, so as to exactly resemble in its mineral composition and crystalline character that of a typical graphic granite. Until, therefore, the specimens were examined chemically, and by a microscopist thoroughly able to give an opinion as to the difference between crystalline and organic structure, he was inclined to hold to the view he now expressed.

Mr Thomson also exhibited two new genera of Carboniferous corals, one of which he had named *Carcinophyllum Kirsopi*, in honour of the gentleman from whom he had received the specimen. He also showed and made some remarks upon a beautiful series of type specimens of Belgian corals sent him by Prof. de Koninck of Liége.

A vote of thanks was then accorded to all the gentlemen who had read papers or exhibited specimens.

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THE GEOLOGICAL SOCIETY OF GLASGOW.

ABSTRACT of the Treasurer's Accounts for Year ending 30th September, 1874.

REVENUE.

RECEIPTS.						
Balance due by the Treasurer at close of last Account,					£1	13 11½
Do. due by Secretaries at do.,					7	15 7
Do. due by Librarian at do.,					2	10 9
Subscriptions—						
Arrears for 1872-73, 2 at 10s.,	£1	0	0			
Subscriptions for current year, 145 at 10s.,	72	10	0			
New Members, 9 at 10s.,	4	10	0			
				78	0	0
Publications sold,				1	17	0
Petty Receipts,				1	4	4
Drawn from Bank,				8	15	0
				£101	16	7½

DISBURSEMENTS.						
Printing *Transactions*,				£20	0	0
Drawings and Engravings,				1	0	0
Rent, Taxes, Insurance, and Attendance,				13	19	10
Publications,				14	1	0
Subscription to Palæontographical Society for four years,				4	4	0
Reporting Sir William Thomson's Address,				2	2	0
Postages—Parcels and Circulars,				1	11	10
Disbursements by Secretary,				6	6	7
Do. by Librarian,				3	2	10
Lodged in Bank,				32	0	0
Balances—						
Cash in Treasurer's hands,	£0	14	7½			
Do. Secretary's hands,	1	9	0			
Do. Librarian's hands,	1	4	11			
				3	8	6½
				£101	16	7½

STOCK.

Current Liabilities,				£58	8	0
Balance of Net Stock,				187	14	5½
				£246	2	5½

Cash in Bank on Deposit Receipt,				£30	0	4
Do. on Current Account,				37	13	7
				67	13	11
Cash in Treasurer's hands,	£0	14	7½			
Do. Secretary's hands,	1	9	0			
Do. Librarian's hands,	1	4	11			
				3	8	6½
Publications, Fossils and Casts,				175	0	0
				£246	2	5½

GLASGOW, *27th October*, 1874.—We have examined the foregoing Accounts, and compared the same with the vouchers, and find them correctly stated and vouched.

(Signed) WM. BAXTER, } *Auditors.*
" C. B. HOGG, }

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THE GEOLOGICAL SOCIETY OF GLASGOW.

ABSTRACT of the Treasurer's Accounts for Year ending 30th September, 1875.

REVENUE.

RECEIPTS.									DISBURSEMENTS.								
Balance due by the Treasurer at close of last Account,							£0	14	7½	Printing *Transactions*,							£93	8	0
Do. in Secretary's hands,							1	9	0	Drawings and Engravings,							10	12	6
Do. in Librarian's hands,							1	4	11	Rent, Taxes, Insurance, and Attendance,							13	2	8
							3	8	6½	Publications for Library,							2	7	0
Subscriptions—										Printing Cards, Circulars, and Stationery,							8	19	6
Arrears for 1873-74, 7 at 10s.,	£3	10	0							Collector's Commission, Postages, and Petty Charges,							4	10	6
Subscriptions for current year, 128 at 10s.,	64	0	0							Disbursements by Secretary,							7	12	2½
New Members, 28 at 10s.,	14	0	0							Do. by Librarian,							3	15	9
							81	10	0	Lodged in Bank,							41	13	8
Life Subscriptions, 16 at £5 5s.,							84	0	0	Balances—									
Publications sold,							3	15	9	Due by Treasurer,					£3	4	8		
Petty Receipts,							2	17	1	Due by Librarian,					1	4	11		
Drawn from Bank,							15	0	0									4	9	7
							£190	11	4½									£190	11	4½

STOCK.

Current Liabilities,							£131	6	6	Cash in Bank on Deposit Receipt,							£63	7	2
Balance to Credit,							196	17	6	Do. on Current Account,							32	17	3
																	96	4	5
										Life Subscriptions,					£84	0	0		
										Less lodged in Bank,					31	10	0		
																		52	10	0
										Cash in Treasurer's hands,					£3	4	8		
										Do. in Librarian's hands,					1	4	11		
																		4	9	7
										Publications, Fossils and Casts,							175	0	0
							£328	4	0								£328	4	0

GLASGOW, *12th October*, 1875.—We have examined the foregoing Accounts, and compared the same with the vouchers, and find them correctly stated and vouched.

(Signed) WM. BAXTER, } *Auditors.*
" C. B. HOGG, }

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REVENUE.

RECEIPTS.						
Balance due by the Treasurer at close of last Account,				£1	13	11½
Do. due by Secretaries at do.,				7	15	7
Do. due by Librarian at do.,				2	10	9
Subscriptions—						
Arrears for 1872-73, 2 at 10s.,	£1	0	0			
Subscriptions for current year, 145 at 10s.,	72	10	0			
New Members, 9 at 10s.,	4	10	0			
				78	0	0
Publications sold,				1	17	0
Petty Receipts,				1	4	4
Drawn from Bank,				8	15	0
				£101	16	7½

DISBURSEMENTS.						
Printing *Transactions*,				£20	0	0
Drawings and Engravings,				1	0	0
Rent, Taxes, Insurance, and Attendance,				13	19	10
Publications,				14	1	0
Subscription to Palæontographical Society for four years,				4	4	0
Reporting Sir William Thomson's Address,				2	2	0
Postages—Parcels and Circulars,				1	11	10
Disbursements by Secretary,				6	6	7
Do. by Librarian,				3	2	10
Lodged in Bank,				32	0	0
Balances—						
Cash in Treasurer's hands,	£0	14	7½			
Do. Secretary's hands,	1	9	0			
Do. Librarian's hands,	1	4	11			
				3	8	6½
				£101	16	7½

STOCK.

Current Liabilities,				£58	8	0
Balance of Net Stock,				187	14	5½
				£246	2	5½

Cash in Bank on Deposit Receipt,				£30	0	4
Do. on Current Account,				37	13	7
				67	13	11
Cash in Treasurer's hands,	£0	14	7½			
Do. Secretary's hands,	1	9	0			
Do. Librarian's hands,	1	4	11			
				3	8	6½
Publications, Fossils and Casts,				175	0	0
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Publications for Library,				2	7	0
Printing Cards, Circulars, and Stationery,				8	19	6
Collector's Commission, Postages, and Petty Charges,				4	10	6
Disbursements by Secretary,				7	12	2½
Do. by Librarian,				3	15	9
Lodged in Bank,				41	13	8
Balances—						
Due by Treasurer,	£3	4	8			
Due by Librarian,	1	4	11			
				4	9	7
				£190	11	4½

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				£328	4	0

Cash in Bank on Deposit Receipt,				£63	7	2
Do. on Current Account,				32	17	3
				96	4	5
Life Subscriptions,	£84	0	0			
Less lodged in Bank,	31	10	0			
				52	10	0
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Petty Receipts,				1	4	4
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				£101	16	7½

DISBURSEMENTS.						
Printing *Transactions*,				£20	0	0
Drawings and Engravings,				1	0	0
Rent, Taxes, Insurance, and Attendance,				13	19	10
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REVENUE.

RECEIPTS.

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Do. in Secretary's hands,				1	9	0
Do. in Librarian's hands,				1	4	11
				3	8	6½
Subscriptions—						
Arrears for 1873-74, 7 at 10s.,	£3	10	0			
Subscriptions for current year, 128 at 10s.,	64	0	0			
New Members, 28 at 10s.,	14	0	0			
				81	10	0
Life Subscriptions, 16 at £5 5s.,				84	0	0
Publications sold,				3	15	9
Petty Receipts,				2	17	1
Drawn from Bank,				15	0	0
				£190	11	4½

DISBURSEMENTS.

Printing *Transactions*,				£93	8	0
Drawings and Engravings,				10	12	6
Rent, Taxes, Insurance, and Attendance,				13	2	8
Publications for Library,				2	7	0
Printing Cards, Circulars, and Stationery,				8	19	6
Collector's Commission, Postages, and Petty Charges,				4	10	6
Disbursements by Secretary,				7	12	2½
Do. by Librarian,				3	15	9
Lodged in Bank,				41	13	8
Balances—						
Due by Treasurer,	£3	4	8			
Due by Librarian,	1	4	11			
				4	9	7
				£190	11	4½

STOCK.

Current Liabilities,				£131	6	6
Balance to Credit,				196	17	6
				£328	4	0

Cash in Bank on Deposit Receipt,				£63	7	2
Do. on Current Account,				32	17	3
				96	4	5
Life Subscriptions,	£84	0	0			
Less lodged in Bank,	31	10	0			
				52	10	0
Cash in Treasurer's hands,	£3	4	8			
Do. in Librarian's hands,	1	4	11			
				4	9	7
Publications, Fossils and Casts,				175	0	0
				£328	4	0

GLASGOW, *12th October*, 1875.—We have examined the foregoing Accounts, and compared the same with the vouchers, and find them correctly stated and vouched.

(Signed) WM. BAXTER, } *Auditors.*
" C. B. HOGG, }

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ADDITIONS TO THE LIBRARY.

SESSIONS 1874–75, 1875–76.

Arctic Expedition, Manual and Instructions for the, 1875.
Belfast Naturalists' Field Club. Annual Reports. 1873–74, 1874–75, 1875–76.
„ Guide to, and the adjacent countries, by Members of the Belfast Naturalists' Field Club, 1874.
Berlin. Zeitschrift für die Ges. Nat. Wis$^{n.}$ July to December 1874.
Boston. Society of Natural History:—
„ Memoirs. Vol. II. Part III. Nos. 3, 4, and 5.
„ „ „ „ IV. „ 1, 2, 3, and 4.
„ Proceedings. Vol. XVI. Parts III. and IV.
„ „ „ XVII. „ I., II., III., and IV.
„ „ „ XVIII. „ I. and II.
„ On the Spiders of the United States. By N. M. Hentz, M.D.
Berwickshire Naturalists' Club. Proceedings for 1874–75.
Bristol. Naturalists' Society. Proceedings. New Series. Vol. I. Part II. 1874–75.
Bristol. Naturalists' Society. Laws and List of Office-Bearers, etc.
Brussels. Annales de la Société de Belgique. Tome I. 1874–75.
„ Bulletin de l'Academie Roy. de Belgique. 1874–75. 4 Vols.
„ Annuaire „ for 1875–76. 2 Vols.
Cairo. Soc. Khedivivrale de Geographie. Constitution and Laws, and Inaugural Address of President. 1875.
Canadian Naturalist. Vol. VIII. No. 2.
Christiania. Geologiste Undersgelser. Troms. Amt. Karl Peterson.
„ Troms Amts Orografi. do.
„ Beretring om nogle Undersgelser. O. E. Schitz.
„ Om Kromjernsten i serpentin. Amund Helland.
„ Det Kongelige Norske Ved-Selskabs Skrifter. Trondjeim. 1868.
„ On Giants Cauldrons. By S. A. Sexe.
„ On Glacial-formationem. By Prof. Theodor Kjerulf.
Cornwall. Journal of Royal Institution. Nos. XVII. and XVIII. 1875–76.
Cotteswolds Naturalists' Club. Proceedings for 1872–73.
Dresden. Sitzungsberichte der Natur. Gesell. Isis Jahrgang. October to December, 1874. January to June 1876.

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Dublin. Royal Geological Society of Ireland. Proceedings. New Series. Vol. IV. Part I.
Edinburgh. Royal Physical Society. Proceedings. 1874–75
„ Geological Society. Vol. II. Parts II. and III.
Glasgow. Natural History Society. Vol. II. Parts I. and II.
„ Philosophical Society. Proc. Vol. IX. Nos. 2, 3, 1874–76.
India. Records of Geol. Survey. Vol. VI. Parts I., II., and III. 1873.
„ Memoirs of do. Vol. X. „ I. „
Liége. Mem. de la Société Royale. Dme. Serie. Vol. IV. Nov. 1874.
Lille. Mem. de la Société Geologique du Nord. 1876.
Liverpool. Lit. and Phil. Society. Proceedings. 1872–73 and 1874–75.
„ Geological Society. Proceedings. 1872, 1873, and 1874.
London. Geologists' Association. Proceedings. Vol. IV. Nos. 3, 6, & 8.
„ Annual Reports and Lists of Members. 1874–75.
„ Geological Society's Quart. Journal. Nos. 123, 124, 125, and 126.
„ do. List. November 1875.
Manchester. Geological Society. Transactions. Vol. XIII. Parts X. and XI. Vol. XIV. Part III.
Milan. Societa Italiana di Scienii Naturali. Vol. XVI. Nos. 3 and 4, Vol. XVII. Nos. 1, 2, 3, and 4. Vol. XVIII. Nos. 1, 2, 3, and 4.
Moscow. Bulletin de la Société Imperiale. 1875. Nos. 1, 2, 3, and 4.
„ do. do. 1876. No. 1.
Munich. Sitz. des Mat. Phys. der. K. K. Acad. de Vissen. 1875. Heft. 1, 2, and 3. 1876. Heft. 1.
Orleans. Archives of Science. Vol. I. No. 6.
Otago. Geology of.
Paris. Bulletin de la Société Geologique de France. June 1875 to September 1876.
Philadelphia. Proceedings of Academy of Nat. Sciences. 1874 and 1875.
„ do. American Phil. Society. 1874 and 1875.
Pisa. Atti della Societa Toscana. Vol. I. 1876. Vol. II. Fasc. 1. 1876.
St. Louis. Transactions of Acad. of Sciences. Vol. III. No. 2.
Vienna. Jahrbuch der K. K. Geol. Reichsanstalt. Nos. 1 and 2. 1875.
„ Sitzungberichte der K. Acad. der Wissenschaften. Math. Natur. 1873, No. 10; 1874, Nos. 2, 3, 4, 5, 6, and 7.
Warwickshire. Nat. Hist. and Archæol. Society's Reports. 1875 and 1876.
Washington. Department of Agriculture. Reports. 1874.
„ Smithsonian Report. 1873.
„ Report of Geol. Survey of Missouri. Broadhead.
„ do. do. Atlas.
„ U.S. Survey. Birds of the North-west. Cottes.
„ „ Cretaceous Flora. Lesquereux.
„ „ Structure and Relations of Dinichthys. J. S. Newberry.

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Washington. U.S. Survey. Report on Dakota. By William Ludlow.
„ Vegetable Remains in Drift Deposits. N. H. Winchell.
„ Explorations in Minnesota. Col. Whittesley.
„ Invertebrate Palæontology. F. B. Meek.
„ Monograph of the Geomedrid Moths. A. S. Packard.
„ Bulletin of the Survey. Second Series. Nos. 2, 3, and 4.
„ Survey of Minnesota for 1874 and 1875. N. H. Winchell.
„ Catalogue of Publications of Survey. F. V. Hayden.
„ Surveys West of the Mississipi, and list of Elevations.

Watford. Transactions of Nat. Hist. Soc. Vol. I. Parts I., II., and III.

MISCELLANEOUS.

Brady. Fossil Foraminifera of Sumatra.
Croll, James. On Theories of Oceanic Circulation.
Hunter, Dr. Vertical Section of Carboniferous Strata. Part I.
Hutton, F. W., F.G.S. Geology of Otago. Dunedin, 1876.
Jones, F. R. On Woolwich and Reading Beds at Reading.
Jones and Kirkby. Notes on some Carboniferous Ostracoda from Russia.
Recketts. Cause of the Glacial Period.
do. Metamorphic Rocks of Malvern Range.
Winchell, N. H. Twenty-seven Pamphlets on Geology of Michigan, etc.
Wright. J. List of Cretaceous Microzoa of North of Ireland.

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GEOLOGICAL SOCIETY OF GLASGOW,

INSTITUTED MAY, 1858.

SESSION 1876-7.

President—SIR WILLIAM THOMSON, LL.D., F.R.S., &c.

Vice-Presidents.

For Three Years.	*For Two Years.*	*For One Year.*
JAMES DAIRON.	JOHN YOUNG, F.G.S.	DAVID SANDEMAN.

COUNCIL.

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D. CORSE GLEN, F.G.S.	HUGH M'PHAIL.
JOHN KIRSOP.	JOHN ROBERTSON.
WILLIAM BAXTER.	DANIEL WILSON.
DAVID ROBERTSON, F.L.S., F.G.S.	THOMAS M. BARR.
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Year of Entry.

1859. Davidson, Thomas, F.R.S., F.G.S., Brighton.
1861. Page, David, LL.D., F.R.S.E., F.G.S., Newcastle-on-Tyne.
1865. Geikie, Archibald, F.R.S., F.G.S., Director of the Geological Survey of Scotland, Edinburgh.
1867. Jones, T. Rupert, F.G.S., Professor of Geology, Royal Military College, Sandhurst.
1867. Kirkby, James W., Pirnie Colliery, Leven, Fifeshire.
1867. Woodward, Henry, F.G.S., British Museum, London.
1867. M'Chesney, Joseph H., Professor of Geology, University of Chicago, U.S.
1871. Hull, Edward, M.A., F.G.S., Director of the Geological Survey of Ireland, Dublin.
1872. Thomson, Sir William, LL.D., F.R.S., &c., Professor of Natural Philosophy, University of Glasgow, *President.*
1872. Young, John, M.D., F.G.S., &c., Professor of Natural History, University of Glasgow.
1872. De Koninck, M. L., Professor of Natural History, Liege.

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HONORARY ASSOCIATES.

1867. Bryce, James, LL.D., F.G.S., Edinburgh.
1867. Struthers, Thomas, Academy, Larkhall.
1867. Croll, James, LL.D., &c., Geological Survey of Scotland, Edinburgh.
1871. Crosskey, Rev. H. W., F.G.S., Birmingham.
1871. Horne, James, Eastbourne, Sussex.
1871. Farie, James, Canonbury, London.
1873. Keddie, William, F.R.S.E., Glasgow.

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1867. Fraser, Rev. Dr., Free Church Manse, Paisley.
1864. Grierson, T. B., M.D., Thornhill, Dumfriesshire.
1867. Gordon, Rev. Dr., Manse of Birnie, Elgin.
1866. Gloag, Rev. Dr. Paton J., Manse, Galashiels.
1864. Hunter, Dr. John R. S., Daleville, Braidwood, Carluke.
1867. Hunter, James, Ironmaster, Coltness.
1867. Kerr, David, Wemyss Colliery, Fifeshire.
1867. Linn, James, Livingstone.
1864. Mitchell, Rev. Hugh, Craig, Montrose.
1867. Sommerville, George, Thornliebank.
1865. Winchell, Alex., Professor of Geology, University of Michigan, U.S.
1866. Myers, Rev. Edward, F.G.S., 20 Summerhill Terrace, Birmingham.
1867. Rankin, D. R., Surgeon, Carluke.
1867. Grossart, William, Surgeon, Salsburgh, Holytown.
1867. Slimon, Robert, Surgeon, Lesmahagow.
1867. Craig, Robert, Langside, Beith.
1859. Dougall, John, M.D., 115 Paisley Road, Glasgow.
1871. Jamieson, T. F., F.G.S., Ellon, Aberdeenshire.
1871. Ward, John, Longton, Staffordshire.
1871. Molyneux, William, F.G.S., Burton-on-Trent.
1871. Jack, R. L., Geological Survey of Scotland, Edinburgh.
1871. Kinahan, G. H., Geological Survey of Ireland, Dublin.
1873. Geikie, James, F.R.S.E., F.G.S., Geological Survey of Scotland, Edinburgh.

RESIDENT MEMBERS.

Those marked with * are Life Members.

1876. Aitken, John, 314 Renfrew Street, Glasgow.
1865. Alexander, George R., 11 Sardinia Terrace, Glasgow.
1868. Allan, Archibald B., C.E., 3 Argyle Terrace, Queen's Park.
1874. Allan, James, 76 Watt Street, Kinning Park, Glasgow.
1876. Allan, James, 98 West George Street, Glasgow.
1871. Anderson, Richard, F.G.S., 130 Strand, London, W.C.
1872. Annan, Thomas, Burnbank Road, Hamilton.
1858. Armstrong, James, 16 Albert Drive, Crosshill.

1874. Bailey, James Lambert, S.S.C., Ardrossan.
1875.*Bain, Hon. James, 3 Park Terrace, Glasgow.

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1877. Balloch, Robert, 88 Union Street, Glasgow.
1867. Bannerman, David, 9 Waterloo Street, Glasgow.
1872. Barr, Thomas M., C.E., 16 Dalhousie Street, Glasgow.
1872. Baxter, William, 14 Gibson Street, Hillhead.
1874.*Belch, John, 22 Dumbarton Road, Glasgow.
1860. Bell, Dugald, 115 St Vincent Street, Glasgow.
1875. Bennett, J. H., 50 Gordon Street, Glasgow.
1867. Bennie, James, Geological Survey of Scotland, Edinburgh.
1877. Blair, Matthew, 104 Causeyside, Paisley.
1876. Brown, J. D., 23 Cowcaddens, Glasgow.
1875. Brown, Thomas, 23 Miller Street, Glasgow.
1867. Buchanan, James, 36 London Street, Glasgow.
1877. Buchanan, John, 230 Duke Street, Glasgow.
1866. Burnet, John, 167 St. Vincent Street, Glasgow.
1861. Burns, John, 103 Main Street, Anderston, Glasgow, *Joint Secretary.*
1876. Burns, Walter, 42 Virginia Street, Glasgow.

1872. Cameron, Donald, 11 Preston Street, Cathcart Road, Glasgow.
1877. Cameron, Peter, 23 Exchange Square, Glasgow.
1873. Cameron, Robert, 1 North Claremont Street, Glasgow.
1877. Campbell, John M., City Industrial Museum, Kelvingrove Park, Glasgow.
1872. Campbell, Thomas M., 10 Carrick Street, Glasgow.
1865. Carrick, John, 74 Hutcheson Street, Glasgow.
1875.*Clavering, Thomas, 21 St. Vincent Place, Glasgow.
1866. Coghill, William, 263 Argyle Street, Glasgow.
1875.*Collins, William, 3 Park Terrace, East, Glasgow.
1865. Colquhoun, Hugh, M.D., Anchorage, Bothwell.
1866. Connal, Michael, Virginia Buildings, Glasgow.
1877. Coulman, George, 3 M'Aslan Street, Glasgow.
1877. Coulthurst, Alameth, 6 St. James' Street, Paisley.
1875. Coutts, James, 44 Dorset Street, Glasgow.
1874. Cox, C. C., Retford.
1860. Crawford, Ebenezer, Eagle Foundry, Port Dundas, Glasgow.
1860. Crawford, W. C., Eagle Foundry, Port Dundas, Glasgow.

1861.*Dairon, James, 4 Garden Street, Glasgow, *Vice-President.*
1866.*Dalglish, Robert, 28 St. Vincent Place, Glasgow.
1877.*Dansken, John, 102 Bath Street, Glasgow.
1874. Darling, George E., 247 West George Street, Glasgow.
1876. Dixon, E. M., 11 Hopetoun Place, Glasgow.
1876. Dobie, James, 5 Maxwelton Place, Glasgow.
1867. Drew, Alexander, 149 West George Street, Glasgow.
1875.*Dron, John, 79 Hill Street, Garnethill, Glasgow.
1872. Duncanson, John, 28 Raglan Street, Glasgow.
1875. Dunlop, E. D., 129 Trongate, Glasgow.
1868. Dunn, William, 72 Great Clyde Street, Glasgow.
1872. Dunsmore, John, Kirkintilloch.

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1872. Eadie, George, 1 Hampton Terrace, Mount Florida.
1869. Evans, Mortimer, C.E., 97 West Regent Street, Glasgow.

1872. *Farquhar, John, Towerbank, Lenzie.
1865. Faulds, Robert, junior, 61 Parliamentary Road, Glasgow.
1874. Fawcett, Archibald, 13 Allanton Terrace, Glasgow.
1867. Fergus, Andrew, M.D., 41 Elmbank Street, Glasgow.
1867. Ferguson, William, F.L.S., F.G.S., of Kinmundy, 134 George Street, Edinburgh.
1877. Ferguson, William, 112 Main Street, Maryhill.
1869. Fisher, Donald, 183 St. Vincent Street, Glasgow.
1870. Fletcher Thomas, 37 Bath Street, Glasgow.
1872. Forsyth, David, M.A., 19 Great Western Road, Glasgow.
1872. Forsyth, Matthew, 191 West George Street, Glasgow.
1875. Fulton, David, Craiglee, Dennistoun.
1870. Fyfe, John, 32 Candleriggs, Glasgow.

1874. Galbraith, James, LL.B., 68 Bath Street, Glasgow.
1866. Gale, James M., C.E., Corporation Water Works, Glasgow.
1875. Gibson, Rev. R. M., 4 Maule Terrace, Partick.
1877. Gillespie, Archd., Corporation Water Co., Miller Street, Glasgow.
1873. Gilmour, Thomas, M.D., 49 King Street, Tradeston, Glasgow.
1866. Glen, David Corse, C.E., F.G.S., 14 Annfield Place, Glasgow.
1868. Gordon, John, 124 Bath Street, Glasgow.
1877. Gordon, W. D., 293 Sauchiehall Street, Glasgow.
1859. Gossman, Adam, 79 Robertson Street, Glasgow.
1877. Graham, M. M., Rowanlea, Pollokshields.
1873. Granger, Allan, South Molton, Devonshire.
1866. Grant, James, 55 Grant Street, Glasgow.
1873. Gray, Duncan, 1 Viewfield Terrace, Pollokshields.
1874. Gray, James (at Miss Kilpatrick's), 12 Dalhousie Street, Glasgow.
1866. Gray, James, M.D., 15 Newton Terrace, Glasgow.

1872. Hamilton, Archibald, C.E., Clyde Navigation Office, Robertson Street, Glasgow.
1868. Hamilton, James, 132 West Regent Street, Glasgow.
1877. Hamilton, Robert, Coatdyke, Airdrie.
1873. Hart, Thomas, 63 Renfield Street, Glasgow.
1874. Harvie John, 27 Union Street, Glasgow.
1876. Henderson, James, 19 West Nile Street, Glasgow.
1874. Hill, Alexander, Park House, Queen's Park, Glasgow.
1877. Hill, Thomas N., 209 St. Vincent Street, Glasgow.
1872. Hogg, C. P., C.E., 175 Hope Street, Glasgow.
1866. Hood, Walter, 2 Royal Exchange Square, Glasgow.
1870. Horne, R. R., Mount Vernon Colliery, Tollcross.
1873. Howie, Richard, School House, Largs.
1866. Hunt, Edmund, C.E., 87 St. Vincent Street, Glasgow.
1876. Hunter, James, 1 Elgin Terrace, Partickhill.

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1867. Hunter, Matthew, 70 Union Street, Glasgow.
1859. Hutchison, Alexander, 119 Hope Street, Glasgow.
1866. Hutton, William R., 77 Renfield Street, Glasgow.
1877. Hyslop, George R., F.C.S., F.R.S.S.E., Glasgow.
1872. Hyslop, Peter S., 175 Hope Street, Glasgow.

1870. Ker, William, 27 West George Street, Glasgow.
1872. Kerr, Hugh B., 60 Lumsden Street, Overnewton.
1875. Kerr, Robert, 37 Centre Street, Glasgow.
1877. Kincaid, Thomas, 9 Lansdowne Crescent, Glasgow.
1874. King, Thomas, 110 Hill Street, Garnethill, Glasgow.
1860. Kirsop, John, 98 Argyle Street, Glasgow.
1867. Knox, Adam, 10 Clayton Terrace, Dennistoun.
1872. Knox, John, 25 Bath Street, Glasgow.
1877. Kyle, Alex., 95 Dundas Street, Glasgow.

1874. Lamb, Thomas, 190 Parliamentary Road, Glasgow.
1867. Lean, Daniel, Reid Street, Bridgeton, Glasgow.
1877. Leck, William, 122 Wellington Street, Glasgow.
1870. Leggat, Rev. Wm., 153 Greenhead Street, Glasgow.
1875. Leitch, Alexander, 252 Sauchiehall Street, Glasgow.
1873. Long, John Jex, 12 Whitevale Street, Glasgow.

1873. Maddever, Dr., Rothesay.
1874. Marshall, Robert, 173 St. Vincent Street, Glasgow.
1871. Mason, Robert, 29 West George Street, Glasgow.
1877. Mathieson, Robert, 205 Watt Street, Paisley Road, Glasgow.
1869. Maxwell, Andrew, 88 Cadogan Street, Glasgow.
1875. Mayer, John, F.C.S., 2 Linden Terrace, Pollokshields.
1875. Millar, David S., 8 Royal Crescent, West, Glasgow.
1867. Millar, James, 340 Cathcart Road, Glasgow.
1867. Millar, John (J. Black & Co., 23 Royal Exchange Square, Glasgow.
1876. Miller, Arch., Shawlands Academy, Crossmyloof.
1866. Miller, James, Dalmarnock Cottage, Dalmarnock.
1874. Miller, J., 13 Robertson Street, Glasgow.
1873. Milligan, W. J., 11 Stonefield Terrace, Glasgow.
1866. Moore, Henry, 49 West George Street, Glasgow.
1867. Moore, William, 49 West George Street, Glasgow.
1859. Morris, Robert, 2 Oswald Street, Glasgow.
1871. Morrison, William, jun., 129 Hope Street, Glasgow.
1865. Mossman, John, 83 North Frederick Street, Glasgow.
1867. Muir, George, 173 George Street, Glasgow.
1877.* Muirhead, Henry, M.D., Bushy Hill, Cambuslang.
1877. Müller, Robert M., C.E., Engineer's Office, G. & S.-W. Ry. Co., Glasgow.
1874. Munro, Alexander, 34 Dundas Street, Glasgow.
1874. Munro, John, 87 Wellington Street, Glasgow.
1859. Murdoch, James Barclay, 47 Oswald Street, Glasgow, *Corresponding Secretary.*

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1875. Murdoch, Robert, 8 Burnbank Gardens, Glasgow.
1875. Murdoch, William, 30 Hope Street, Glasgow.
1870.* Murray, David, 13 Fitzroy Place, Glasgow.
1871. M'Ara, Alexander, 83 Jamaica Street, Glasgow.
1873. Macbeth, Daniel, Ashburn, Ascog, Rothesay.
1875. M'Birnie, J. M'Farlane, M.D., Baldarroch House, Milton of Campsie
1866. M'Clelland, Andrew S., 115 St. Vincent Street, Glasgow.
1875. Maconechy, Robert, 64 St. Vincent Street, Glasgow.
1874. M'Dougall, Daniel, 8 Jail Square, Glasgow.
1877.* Macfarlane, George, 179 West George Street, Glasgow.
1875. M'Gilchrist, John, 113 Hydepark Street, Glasgow.
1867. M'Glashan, John, 114 Candleriggs, Glasgow.
1874. M'Gregor, Donald, 123 Cambridge Street, Glasgow.
1875. M'Kay, R., 26 George Street, Glasgow.
1876. M'Lauchlan, John, 159 Cowcaddens, Glasgow.
1877. Maclay, William, 5 Hampden Terrace, Mount Florida.
1876. M'Nee, Forrest, 21 Roselea Drive, Dennistoun.
1876. M'Nellan, J. W., C.E., Engineers' Office, Caledonian Railway, Glasgow.
1868. M'Phail, Hugh, 551 Sauchiehall Street, Glasgow.

1864. Naismith, Thomas, 233 Duke Street, Glasgow.
1865. Napier, J. W., 249 Renfrew Street, Glasgow.
1875. Neilson, D. M., 48 Gordon Street, Glasgow.
1870. Neilson, James, jun., 122 Finlay Drive, Dennistoun.
1868. Neilson, Richard, 110 John Street, Glasgow, *Librarian.*
1875. Niven, Thomas O., C.E., 115 Wellington Street, Glasgow.
1867. Norman, John, 20 Windsor Terrace, St. George's Road, Glasgow.

1869. Orr, John, 8 Newhall Terrace, Glasgow.

1875. Pearson, D., 215 Sauchiehall Street, Glasgow.
1867. Pratt, Arthur, 225 West George Street, Glasgow.
1869. Pratt, David, 72 Waterloo Street, Glasgow.
1877. Pratt, Gavin, 103 Renfrew Street, Glasgow.

1876. Ramage, William, 41 Hope Street, Glasgow.
1873. Rankine, David, C.E., 157 St. Vincent Street, Glasgow.
1875.* Raphael, Robert, 9 St. James' Terrace, Hillhead.
1866. Rattray, John, 94 Renfield Street, Glasgow.
1865. Reid, John, Hyndford Cottage, Lanark.
1872. Reid, John, Yorkhill Gate, Partick.
1866. Reid, J. G., 2 Sandyford Place, Glasgow.
1874. Renwick, John, Mary's Place, Maryhill.
1877. Rhind, John, 82 Hill Street, Garnethill, Glasgow.
1875. Riddell, Hugh, 130 Hope Street, Glasgow.
1867. Robertson, Archibald, 25 Queen Street, Glasgow.
1867. Robertson, David, F.L.S., F.G.S., 42 Kelvingrove Street, Glasgow.

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1872. Robertson, David, 205 Hope Street, Glasgow.
1868. Robertson, Joseph, 110 John Street, Glasgow.
1859. Robertson, Dr. Jas., Clydesdale House, Renfrew.
1866. Robertson, John, 10 Valeview Terrace, Cathcart.
1877. Robertson, John, Whiteinch.
1875. Rodgers, William, C.E., 131 Hope Street, Glasgow.
1874.*Ross, John M., 184 Parliamentary Road, Glasgow.
1868. Ross, Robert, 176 St. Vincent Street, Glasgow.
1877.*Rottenburg, Paul, 13 Albion Crescent, Dowanhill.
1865. Rowan, David, 22 Woodside Place, Glasgow.
1871. Rowan, Thos., 194 St. Vincent Street, Glasgow.
1871. Russell, James, 6 Greenlodge Terrace, Greenhead
1877 Russell, J. S., 97 Wellington Street, Glasgow.

1861.*Sandeman, David, 11 John Street, Glasgow, *Vice-President.*
1872. Schuman, Sigismund, 12 Royal Bank Place, Glasgow.
1873. Scott, Thomas, 1 Clutha Place, Glasgow.
1877. Severn, Thomas, 20 Great Western Road, Glasgow.
1871.*Smellie, Thos. D., 213 St. Vincent Street, Glasgow.
1875. Smith, James, 94 Dundas Street, Glasgow.
1865. Smith, John, Eglinton Ironworks, Kilwinning.
1867. Smith, John P., C.E., Haughead Cottage, Govan Road, Glasgow.
1870. Somerville, James, 4 Clayton Terrace, Dennistoun.
1871. Somerville, Joseph, 471 St. George's Road, Glasgow.
1868. Steel, James, 302 St. Vincent Street, Glasgow.
1876. Stewart, David, Engineer, G.P.O., George Square, Glasgow.
1866. Stewart, Hugh, Thornliebank.
1858. Stewart, James, 29 Royal Exchange Square, Glasgow.
1875. Stewart, James, 172 West Nile Street, Glasgow.
1874. Stewart, John, 12 Ure Place, Glasgow.
1873. Stewart, Robert M., 28 Abbotsford Place, Glasgow.
1867. Stewart, Thomas P., 55 Anderston Quay, Glasgow.
1874. Stevenson, John, Rowanbank, Trefoil Avenue, Shawlands.

1876. Taylor, James, jun., 129 High John Street, Glasgow.
1874. Taylor, Joseph, 6 Main Street, Anderston, Glasgow.
1866. Taylor, William, 144 Wellington Street, Glasgow.
1875. Telfer, David, 6 Charing Cross, Glasgow.
1875.*Tennant, John, of St. Rollox, 195 West George Street, Glasgow.
1860. Thomson, George, 69 Ingram Street, Glasgow.
1858. Thomson, James, F.G.S., 3 Abbotsford Place, Glasgow.
1874. Thompson, John, Deaf and Dumb Institution, Mount Florida.
1874. Tuckwell, J., 282 Buchanan Street, Glasgow.
1868. Turnbull, J., 96 Renfield Street, Glasgow.
1875. Turnbull, John, 11 Walmer Crescent, Glasgow.

1873. Waddell, Arthur R., Rosemount House, Airdrie.
1876. Waghorn, George A., Brassey & Co., Great Clyde Street, Glasgow.

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Year of Entry.

1866. Walker, R., Union Villa, Helensburgh.
1876. Walker, Robert, Jun., 8 Ingram Street, Glasgow.
1866. Walton, George K., 2 Moray Place, Queen's Park, Glasgow.
1874. Watson, W. W., City Chamberlain, County Buildings, Glasgow.
1874. White, James, 220 Hope Street, Glasgow.
1874. White, James, Free Normal School, Glasgow.
1875. White, John, 150 Holland Street, Glasgow.
1877. White, J. C., Oakfield Cottage, University Avenue, Hillhead.
1864. Whitelaw, Alexander, 87 Sydney Street, Glasgow.
1875. *Whitelaw, Alex., M.P., Gartsherrie House.
1877. Whitelaw, Thomas, Cardross.
1866. Wight, John, C.A., 150 Hope Street, Glasgow, *Treasurer.*
1876. Wilkes, George Stewart, Engineer, G.P.O., George Square, Glasgow.
1860. Wilson, Daniel, 85 Wellington Street, Glasgow.
1867. Wilson, Hugh, 53 Garscube Road, Glasgow.
1870. Wilson, James E., 1 Ranfurly Place, Paisley Road, Glasgow.
1874. Wilson, John, 4 Washington Street, Glasgow.
1877. Wilson, Thos. L., Clydesdale Bank, Glasgow.
1869. Wingate, W. G., 12 Garthland Street, Glasgow
1858. Wünsch, E. A., F.G.S., 88 St Vincent Street, Glasgow

1859. Young, George, 54 York Street, Glasgow.
1872. Young, James, 103 West Regent Street, Glasgow.
1859. *Young, John, F.G.S., Hunterian Museum, University, Glasgow, *Vice-President.*
1868. Young, William, 88 St. George's Road, Glasgow.
1875. *Yuile, Thos. Smith, 119 Trongate, Glasgow.
1867. Yule, John, 23 Carlton Place, Glasgow.

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